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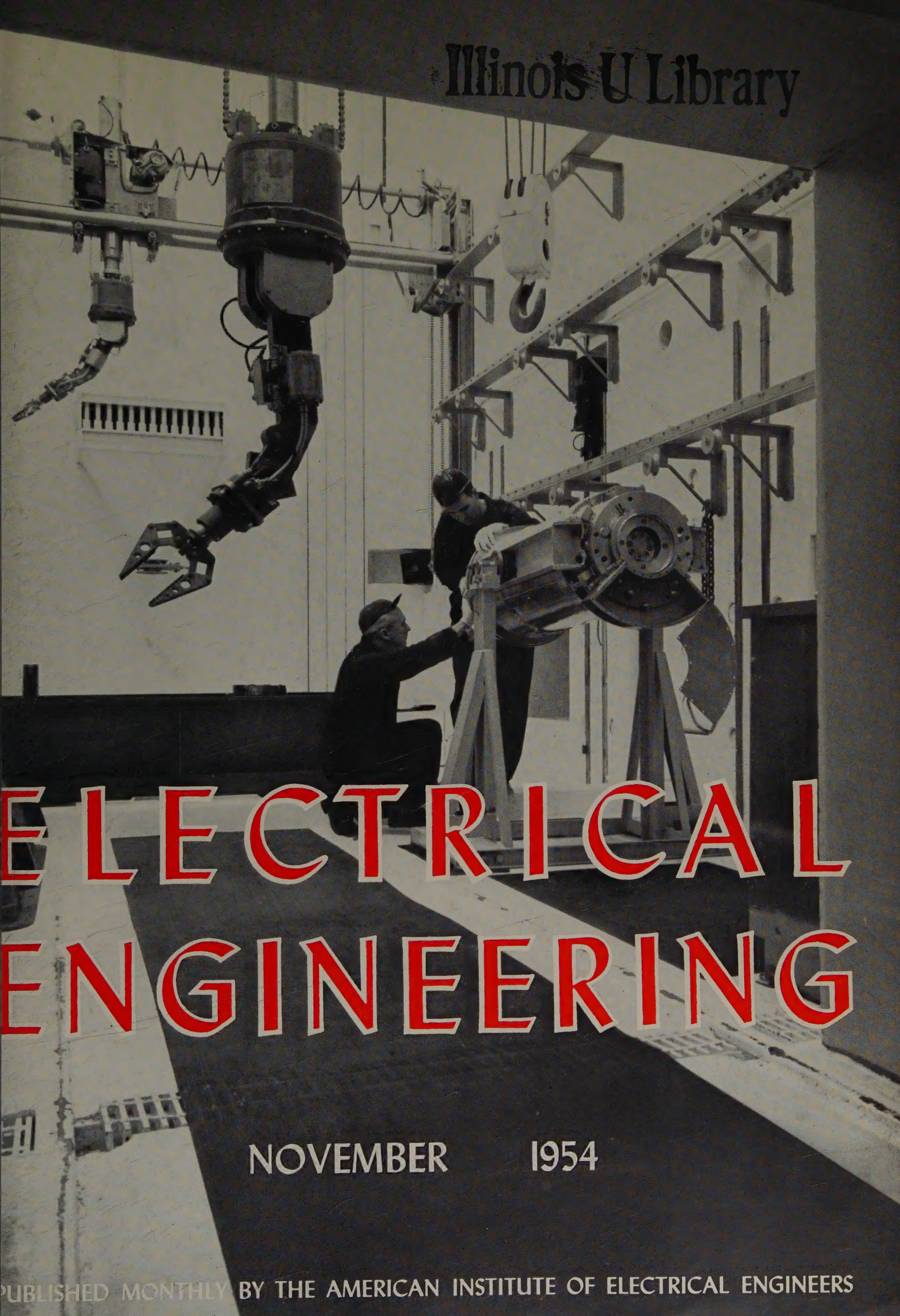
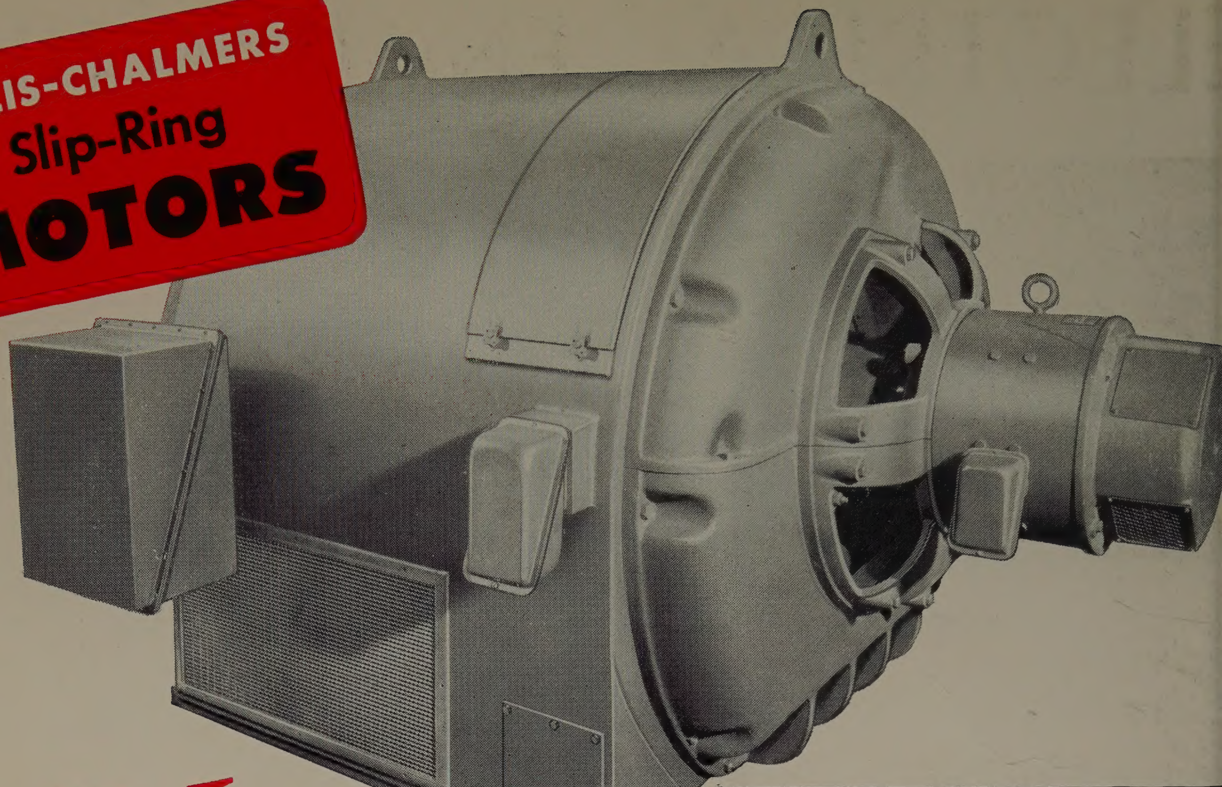


ELECTRICAL ENGINEERING

NOVEMBER 1954

PUBLISHED MONTHLY BY THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

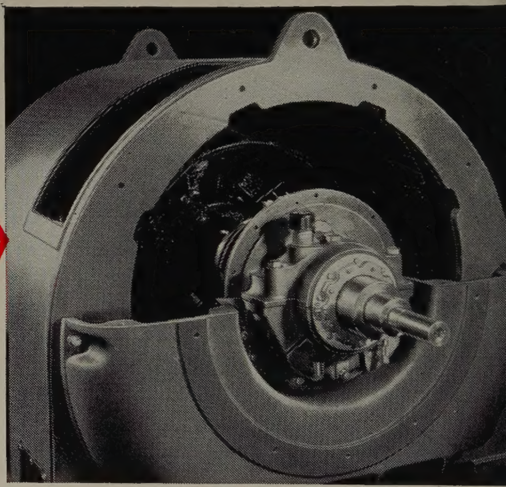
ALLIS-CHALMERS
Slip-Ring
MOTORS



new DESIGN...

more protection with

full accessibility



* New Allis-Chalmers slip-ring motor wit
inspection cover and upper half of en
shield removed. Note accessibility o
brushes, protection of bearing.

ALLIS-CHALMERS LARGE SIZE SYNCHRONOUS AND WOUND-ROTOR MOTORS have been completely redesigned with longer stator yokes and shorter end shields. Collectors and brushes are located inside the yoke for protection against physical damage, dripping moisture, dust and dirt.

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Easy maintenance — Even though the new desig
offers maximum protection to brushes and collec
tors, internal parts are fully accessible for inspectio
and maintenance through large openings in th
stator yoke. Opening covers are readily remove
and are secured during operation by easy-operatin
self-locking fasteners.

Get details now — This new design is availabl
from approximately 250 hp at 300 rpm and up, i
drip-proof and splash-proof construction. Call you
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Ask for Bulletin 05R8183.

A-44

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ELECTRICAL ENGINEERING

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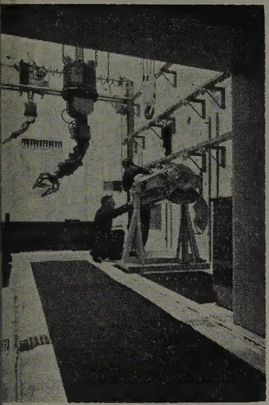

NOVEMBER
1954

The Cover: One of the most unique tools of the atomic age is the "hot cell" or "hot cave." This one, located at the National Reactor Testing Station, Idaho. For detail of "hot cave," see article by P. A. Halpine, p. 975, and "Of Current Interest" section, October, *Electrical Engineering*, p. 955.

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The first cost of air-cooled transformers is not always the total final cost

1. *Because*

Some air-cooled dry-type transformers cost more to install than others.

1. *But*

SORGEL air-cooled dry-type transformers cost less to install because they are all self-contained in a single unit — either single phase or 3-phase — equipped with substantial wall brackets with slots for bolts, or with floor mounting base. No separate brackets to make or buy. Roomy connection compartment with wide choice of knockouts. Equipped with solderless terminal lugs, and permanent connection diagram.

2. *Because*

Some require a larger rating for a certain load.

2. *But*

SORGEL transformers do not require a larger rating than the load, because they are guaranteed to carry their full rated load continuously. They are so liberally designed that they can safely carry a temporary overload.

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HIGHLIGHTS........

Ten Founding Fathers of the Electrical Science. Michael Faraday's invention of a chemical source of electricity, the voltaic cell, and the discovery of electromagnetic induction opened the way to the full expansion of the electrical age (*pages 966–7*).

Engineering Registration. The author reviews the history of registration as applying to several recognized professions. He explains why all engineers, and especially recent graduates, should concern themselves with thought as to how they can achieve professional registration (*pages 961–2*).

Sources and Properties of Electrical Noise. The concept of noise is of basic importance in a wide variety of electrical problems. Physicists, statisticians, and communication engineers have co-operated to provide a quantitative description of noise-like phenomena. The way useful laws are deduced from appropriate physical models is indicated and examples of experimental verification are included (*pages 1001–06*).

AIEE Fellows. Biographical sketches of members recently elected to the grade of Fellow in the Institute are presented (*pages 1036–37*).

Automatic Alarm Device for CONELRAD Radio Alerting. Special signals from aural broadcast or television stations are the means of informing the public of enemy aerial attack. Such CONELRAD signals automatically trigger this electronic device (*pages 963–5*).

Winter General Meeting. A preliminary program of the activities for the Winter General Meeting to be held January 31–February 4, 1955, in New York, N. Y., is included in this issue (*page 1030*).

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60-Cycle Induction Heating of Steel. In the low-frequency range, commercially available frequencies offer lower operating and first costs. Various factors to be considered in order to take full advantage of 60-cycle induction heating are discussed and conclusions are drawn (*pages 1009–11*).

An Expanded and Modernized Industrial Power System. After briefly describing the original electric power system, the modifications and extensions are discussed together with the supplementary higher voltage system which was installed. The latter, covered in some detail, was planned so that further expansion could be made using similar arrangements and equipment (*pages 1013–6*).

Properties of Plasticizers and Their Relation to Electrical Compounding. Plasticizers are dealt with in relation to volatility and aging characteristics, their effects on resistivity of compounds, and their influence on dry blending rates, together with the effects of clay on the properties of plasticized compounds (*pages 1018–20*).

Characteristics of Magnetic Amplifiers for Industrial Use. Although the magnetic amplifier should not be considered the answer for every application, it does have many uses in regulating circuits. Presentation of its advantages and disadvantages is followed by discussions of regenerative stopping, minor obstacles to be overcome by a designer, specification for an industrial magnetic amplifier, and six typical magnetic amplifier applications (*pages 1023–7*).

Economics of Location of Machine Tools Control Devices. A consideration of the proper arrangement of controls and meters is essential to fully utilize the human efficiency of the machine-tool setup man, operator, maintenance electrician, or mechanic. After discussing the six factors to be evaluated in the layout of a machine tool, 2 specific machines are compared and the savings to be made by utilizing the more efficient one are indicated (*pages 968–72*).

Handling and Viewing of Radioactive Materials. The equipment now available for safely conducting the tests required to evaluate the suitability and for the determination of the performance of power plant materials is described. The deep-water pit is more simple and economical in first cost, while the shielded cells are more advantageous in that many items of conventional testing equipment can be used with little modification (*pages 975–9*).

Bimonthly Publications

The bimonthly publications, *Communication and Electronics*, *Applications and Industry*, and *Power Apparatus and Systems*, contain the formally reviewed and approved numbered papers presented at General and District meetings and conferences. The publications are on an annual subscription basis. In consideration of payment of dues, members (exclusive of Student members) may receive one of the three publications; additional publications are offered to members at an annual subscription price of $2.50 each. The publications also are available to Student members at the annual subscription rate of $2.50 each. Nonmembers may subscribe on an advance annual subscription basis of $5.00 each (plus 50 cents for foreign postage payable in advance in New York exchange). Single copies, when available, are $1.00 each. Discounts are allowed to libraries, publishers, and subscription agencies.

Testing Point-Contact Transistors for Pulse Applications. Methods for making d-c, static, and dynamic measurements are described. Typical measurement results and specifications provide a set of reference values for the recommended measurements (*pages 981–7*).

Magnetostriction and Domain Structure of Materials for Use in Low-Noise Equipment. The range of phenomena called magnetostriction is surveyed considering the viewpoint of the engineer confronted with a problem of audio noise in inductive equipment. Certain special problems arising in connection with the application of domain theory to experimental data obtained on crystal-oriented 3-per-cent silicon-iron alloys are pointed out (*pages 991–4*).

A New Approach to the Problem of Higher Voltage Distribution. This article is one of a group of studies which presents the results of investigations leading to the decision by the Consolidated Edison Company in New York to offer 265/460 volts for certain categories of load (*pages 997–1001*).

Membership in the American Institute of Electrical Engineers, including a subscription to this publication, is open to most electrical engineers. Complete information as to the membership grades, qualifications, and fees may be obtained from Mr. N. S. Hibshman, Secretary, 33 West 39th Street, New York 18, N. Y.

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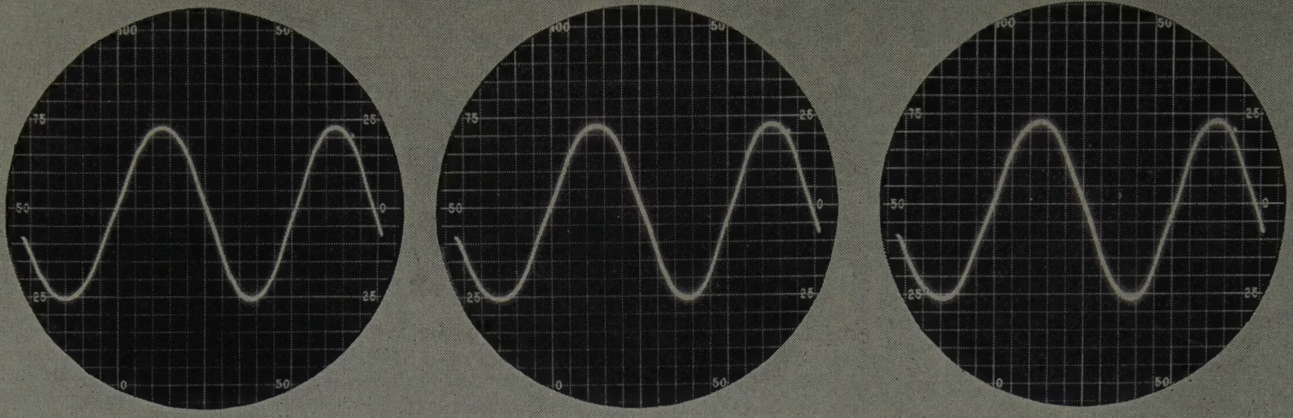
No load

Half load

Full load

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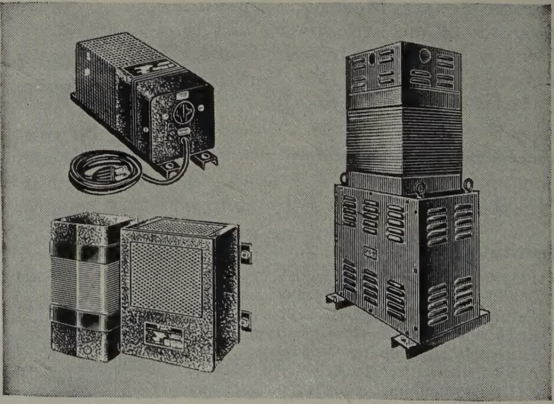
***TYPICAL HARMONIC ANALYSES, TYPE CVH CONSTANT VOLTAGE TRANSFORMER**

	Input Volts	Output Volts	3rd	5th	7th
Full Load	115	115.0	0.77%	1.20%	0.34%
50% Load	115	116.1	1.00	0.70	0.55
No Load	115	116.2	0.65	0.36	0.60

**On production units, the lowest residual harmonic content may occur anywhere between full load and no load.*


TYPICAL MECHANICAL STRUCTURES: The two stabilizers on the left are stock units, the transformer on the right is a "special" in the 7,500va size range.

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Engineering Registration

A. G. STANFORD
FELLOW AIEE

Approximately 45 per cent of those engaged in engineering work are holders of a legal license to practice professionally, as against practically 100 per cent in all the other recognized major professions. With an awakening of professional consciousness, engineers should consider registration as an important contribution towards a greater profession.

THROUGH the medium of professional engineering registration, engineers have a most valuable tool for contributing to the unification of all branches of the profession and, what is equally if not more important, have the only practical method of achieving nation-wide recognition of engineering as a learned profession of high ethical and technological standards.

It is of interest and value to review briefly the history of registration as applying to several recognized professions, from which will be seen some of the reasons why the engineering profession in this country has been slow in gaining the professional recognition it should have. In the following tabulation it will be noted that in comparison with the medical, dental, and legal professions, the engineering profession lags considerably behind the others in initiating and in prosecuting those actions usually associated with legal recognition and general acceptance of professional status:

	Medicine	Dentistry	Law	Engineering
First Licensing Law	1760	1841	1890	1907
First College Course	1765	1840	1779	1828
Accrediting of Curriculum by Professional Societies	1907	1909	1921	1936
National Board of State Examiners	1892	1883	1931	1920
Founding of Professional Society of Licensed Practitioners	1847	1859	1878	1934
Licensed Individuals	170,000	80,000	185,000	180,000
Practicing Individuals	170,000	80,000	185,000	400,000

Engineering, in some form, has been practiced in this country certainly as long as any profession, yet we were many years behind the others in recognizing, through the passage of engineering registration laws, the importance of safeguarding the lives, health, and property of the general public.

The most significant of the figures just given are those which show that in the case of three out of four of the professions which were reviewed the total number of individuals practicing the profession is, for all practical purposes, identical with the total number of individuals who are legally licensed to practice. In the profession of engineering the picture is entirely different, with an estimated total of 400,000 practicing engineering in this country today in its various branches there are only approximately 180,000 or 45 per cent of these individuals who have been licensed to so practice and are legally recognized as engineers.

What are the reasons for the wide diversity in the total numbers of those admittedly practicing engineering and those who have legally accepted their responsibilities to the general public for ethical and professional conduct as expressed through the medium of professional licensure?

EXEMPTIONS

First—a majority of our state registration laws exempt engineers in various employment classifications from the requirement of registration—which is a somewhat queer way of implying that the protection of the life, health, and safety of the general public varies in importance.

Many of the exemptions applying to professional engineer licensure were undoubtedly included in the early registration acts for political purposes and to eliminate group antagonism against the original passage of these laws. Unfortunately these legal distinctions in engineering employment practice have been carried along in varying degree in a majority of the state laws. The far reaching significance of these exemptions also perhaps was not foreseen in the early days of engineering licensure since in the earlier years of the twentieth century the various governmental agencies at federal, state, and local levels, as well as many of the public utilities, did not attempt to handle with their own forces any appreciable amount of the design and the supervision of construction of public works and other engineering projects of that era.

Today there is widespread and continuing growth in employment of engineering personnel by practically all governmental agencies—and at all levels—whose services are utilized in the design and engineering supervision of construction of projects wherein the health, life, and safety of the general public are most assuredly involved. This poses a serious problem both as to adequacy of, and in the administration of, our engineering registration laws. In these days of ever increasing size and complexity of engineering works it is difficult for the layman and the presently registered professional engineers to understand why it is not considered important, as a safeguard to the public, to require certification of technical and professional competence of engineers in these now exempt groups. The law requires this of other individuals on similar work who are either self-employed or are employees of firms, partnerships, and corporations in private practice or

---

Essentially full text of a special article recommended for publication by the AIEE Committee on Registration.

A. G. Stanford is vice-president, Robert and Company, Atlanta, Ga.

otherwise responsibly engaged in engineering work.

In recent years the courts have handed down some interesting and possibly far-reaching decisions wherein damages have been assessed against governmental agencies because registered engineers were not utilized in the design and supervision of construction of engineering works which later failed.

EXAMINATIONS

SECOND—many engineers, both in and out of the exempt groups, have either procrastinated or deliberately refrained from seeking professional engineer registration during the earlier years of their careers. This may have been because of the belief that their work would never be such as would require a professional engineer license, or that such a license might be easier to obtain at a later date, or just plain lack of appreciation and understanding of the long-range social, economic, and professional value of being legally identified as a member of a great profession.

It is not the desire of engineering examining boards to use examinations and other procedures for evaluating the qualifications of applicants for registration with any endeavor to bring about the failure of any applicant or to impose undue hardships in his efforts to achieve professional status. But rather the opposite is true and registration boards are anxious to advance recognition of engineering and to enhance the prestige of the greatest possible number of those who are engaged in engineering work by encouraging such registration. As the primary purpose of our registration laws is for the protection of the life, health, and safety of the public, this imposes upon the members of the registration boards the grave duty of determining, by the various means at their disposal, whether or not each individual applicant is competent, at the time of making his application, to be entrusted with the responsibility of using his technical and professional knowledge in such a manner as will preserve the fundamental objectives of the registration acts. It is the duty of the registration boards to protect the public from the work and representations of the unscrupulous and the incompetent practitioner.

For any young engineer with professional aspirations there is certainly no stigma attached to his failure to successfully pass a written examination. It simply implies that his recollection may have become dimmed on some phases of his academic training which can then be improved by refresher courses or other part-time study.

A majority of the registration boards grant to each applicant the right to take a second examination at a later date without additional cost. As a result of this willingness to expend some additional effort, the applicant will perhaps result in being a much better engineer and also have the inner satisfaction of having accomplished his objective.

VARIATIONS IN LAWS

THIRD—while there is a great deal of similarity in the language of the registration laws in many of our states there are also many wide variations. But perhaps the most noticeable variations arise in the administrative procedures of the various boards. This is largely occasioned by the difference in the number of years in which the engineering registration acts have been enforced in the different states. Wyoming was the first state in 1907 to enact its engineering registration law, while the District of Columbia was the last and final area to establish legal registration for engineers, which was done in 1950.

From this it will be seen that we have some states in which engineering examining boards have been functioning for forty or more years, while at least one board has been functioning for as short a time as four years. As has been customary and proper during the early years of the administration of the registration act in each state, the requirements for professional engineering registration were reduced. This has enabled many engineers to secure registration under the "grandfather clause" in one state while at the same time being ineligible to obtain, with similar qualifications, such registration in many other states. This has caused some confusion and ill feeling at times when these engineers have moved into other states and been refused registration under the reciprocal or interstate registration provisions which are permitted under many of the state laws.

It is also natural that over the years each state registration board has gradually increased the qualifying requirements and have exercised greater vigilance with respect to many borderline cases. This is a very proper and normal procedure in the interest of advancing the quality, prestige, and value of the registration certificate and the protection thus afforded the public. This is a contribution toward the building of an ever stronger profession.

The National Council of State Boards of Engineering Examiners, comprising in membership all of the 52 state and territorial engineering registration boards, has for a long time been working in bringing about uniformity in the provisions of the various state laws, as well as similarity in the administration procedures of these boards. The accomplishment of these objectives is not easy and patience is required. It is the duty of all who are engaged in engineering work or teaching to interest themselves in the work of the engineering registration board in their home state, and to lend their efforts and assistance in securing enactment of amendments to the registration law, where necessary, to bring about greater uniformity with those of other states.

The recent graduates from accredited engineering curricula who have not yet obtained sufficient qualifying experience should act to obtain engineer-in-training certification as the first step in achieving full professional status. All others engaged in engineering work and teaching who are not now registered should concern themselves more with thoughts as to how they can achieve professional registration rather than how to avoid it. In fact they should take those steps that will help swell the present ranks of the 180,000 engineers who now take pride in their recognized position in the engineering profession. The possession of a certificate of registration as a professional engineer is something of which you may always justly be proud.

Automatic Alarm Device for CONELRAD Radio Alerting

R. B. CAREY
ASSOCIATE MEMBER AIEE

One of the requirements of CONELRAD is the need for notification of radio alerts and all clears by receiving radiobroadcast messages from aural and television stations. An alarm device used in conjunction with a broadcast receiver has been designed which will function automatically upon the reception of CONELRAD carrier signals.

THE word CONELRAD is a contraction of the words CONtrol of ELectromagnetic RADiations and is the general name given to required procedures under authority of Executive Order 10,312, dated December 10, 1951, issued by the President of the United States. CONELRAD requirements for most radio services, both government and nongovernment, dictate the need for immediate notifications of "Radio Alerts" and "Radio All Clears" by means of the reception of radiobroadcast messages. Although not required by existing government regulations, an automatic alarm device used in conjunction with a well-designed radio receiver can provide a safe and sure method for receiving such messages.

The purpose of the CONELRAD program is to minimize navigational assistance that might be given by electromagnetic radiations from radio stations under the jurisdiction of the United States to hostile aircraft, guided missiles, or other devices capable of direct attack upon the United States.

The authority for promulgating the CONELRAD plans under Executive Order 10,312 has been delegated to the Federal Communications Commission (FCC) in the case of nongovernment radio services and to the responsible operating agency in the case of government radio services. The FCC CONELRAD plan for standard, FM, and television broadcast stations has been approved and is ready for effective operation. The plans for other nongovernment radio services are in various states of development or co-ordination. CONELRAD plans for the government services are, in a few instances, virtually completed with considerable effort being devoted to the completion of the remainder.

DISSEMINATION OF CONELRAD ALERT

CONELRAD plans will be placed in effect during periods of enemy attack or imminent threat thereof. The order to implement CONELRAD and operate stations in accordance with CONELRAD requirements is called a "Radio Alert." The authorization to return to normal operation is called a "Radio All Clear." The authority to order either of these conditions has been vested in the Department of Defense with further delegation to the Air Defense Command of the United States Air Force. "Radio Alert" and "Radio All Clear" orders are disseminated through several different systems. Only one of these, the alerting system for standard, FM, and television broadcast stations, is available for widespread use. The alarm device described herein is designed for use in this system.

Certain standard, FM, and television broadcast stations in the United States are connected by toll terminal or private-line telephone circuits into networks having their origins at Air Defense Control Centers under the authority of Air Division Commanders. These stations, upon notification through this network that a Radio Alert is in effect, are required immediately to proceed as follows if in operation:

1. Discontinue normal program.
2. Cut the transmitter carrier for approximately 5 seconds.
3. Return the carrier to the air for approximately 5 seconds.
4. Cut the transmitter carrier for approximately 5 seconds.
5. Return carrier to the air.
6. Broadcast a 1,000-cycle steady-state tone for 15 seconds.
7. Broadcast the following CONELRAD "Radio Alert" message:

> "We interrupt our normal program to co-operate in Security and Civil Defense measures as required by the United States Government.
>
> "This is a CONELRAD Radio Alert. Normal broadcasting will now be discontinued for an indefinite period. Civil Defense information will be broadcast in most areas at 640 or 1240 on your regular radio receiver.
>
> "I repeat—
>
> "This is a CONELRAD Radio Alert. Normal broadcasting will now be discontinued for an indefinite period. Civil Defense information will be broadcast in most areas at 640 or 1240 on your regular radio receiver."

8. Remove transmitter carrier from the air for the dura-

A special article recommended for publication by the AIEE Committee on Television and Aural Broadcasting Systems.

R. B. Carey is Federal Communications Commission co-ordinating engineer, CONELRAD, with the 29th Air Division (Defense), Great Falls Air Force Base, Mont.

tion of the alert. (Certain stations return to the air broadcasting on either 640 or 1240 kc.)

CRITERIA FOR AUTOMATIC ALARM

It should be noted that one carrier interruption, two carrier interruptions, or two carrier interruptions followed by a 1,000-cycle tone do not constitute a notification of a radio alert. The prescribed message must also follow. Since the radio alerting system is tested quite frequently at which times both carrier interruptions and the 1,000-cycle tone are used with the announcement omitted, it is evident that a suitable alarm device, whether activated by the carrier interruptions, by the 1,000-cycle tone, or a combination of both, must incorporate provisions for aural monitoring. The general pattern into which an automatic alarm device must fit, therefore, has been established.

A satisfactory CONELRAD alert alarm device should fulfill certain other requirements. It should be capable of reliable operation on either a strong or a weak signal. It should operate in the presence of a high noise level. It must tolerate a reasonable amount of signal fading or power-supply voltage fluctuation. It must be simple to adjust, capable of sustained operation without failure, and if either the alarm device or the associated receiver fails in any manner, the failure must result in an alarm indication. Last, but not least, it should cost as little as possible.

MANY ALARM DEVICES USE RECEIVER AVC VOLTAGE

Although not specifically required by government regulations, there are several thousand CONELRAD alarm devices in operation at the present time. Some of them are quite complicated and costly, using cycling or time-delay relays, 1,000-cycle filters, etc. Most of them, however, are designed to activate upon a simple carrier interruption. The great majority of these utilize the receiver automatic-volume-control (AVC) voltage for control purposes.

Fig. 1 illustrates a typical alarm circuit of this type. This is usually the simplest and most expedient means of obtaining a control voltage for alarm operation; however, it does present several disadvantages. The AVC voltage in a receiver is negative in the presence of an incoming signal and becomes less negative when the signal is removed or becomes measurably weaker. Unless a stage of amplification is used between the receiver AVC voltage and the alarm control tube *V* the polarity of the controlling voltage is maximum negative with maximum incoming signal. To utilize this negative polarity, the alarm relay-control tube is held below cutoff by a normal condition (the presence of an incoming signal). When this incoming signal is interrupted or becomes measurably weaker, the weakening AVC voltage carries the grid of the relay control tube to above cutoff and the tube begins to conduct. This draws plate current through the coil of the control relay *RL* pulling the relay up and activating the alarm. If the control tube fails, the relay coil opens, or the power-supply voltage is removed from the control tube, no amount of change in the AVC voltage can have any effect upon the alarm and the alarm will remain in the "safe" position.

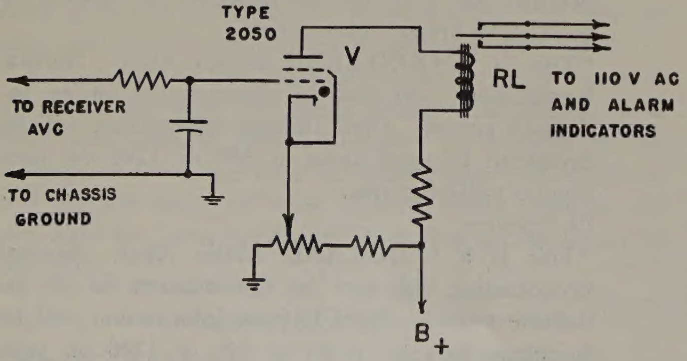


Fig. 1. **Schematic of a typical CONELRAD alarm circuit using the automatic volume control of the broadcast receiver**

Such an alarm has no positive indication of an alarm failure. This is perhaps its worst fault. An alarm of this type generally uses a triode or a grid-controlled thyratron for relay control purposes and is very sensitive to slight signal fading and power-supply-voltage fluctuations. When used with a receiver that does not have a severe AVC voltage fluctuation, this type of alarm is not so adversely affected by such difficulties. However, in that case, the other extreme is reached. Such a receiver generally does not have a sufficient AVC voltage swing between weak-signal and no-signal conditions to affect positive grid control of the tube. It is for these reasons that the author feels the need for a different approach to the problem.

DESCRIPTION OF AUTOMATIC ALARM OPERATION

For control purposes the alarm circuit shown in Fig. 2, designed and constructed by the author, utilizes a portion of the intermediate-frequency (i-f) voltage developed in the receiver. This i-f voltage is obtained from the plate of the final i-f amplifier tube through a small coupling capacitor C_1. An 8- to 50-$\mu\mu$f ceramic trimmer capacitor was found to be suitable and may be adjusted to obtain the desired coupling. This arrangement will usually affect the plate loading of the i-f amplifier tube and a readjustment of the final i-f transformer tuning may be necessary. The i-f voltage obtained from this source is rectified by a germanium diode (type *1N38*) and appears as a positive voltage across a 10-megohm potentiometer R_1. This potentiometer is essentially a voltage divider and is used as a threshold adjustment to apply the proper amount of positive bias to the grid of the control tube V_2. The combination of R_2C_2 in conjunction with that part of R_1 in use determines the time constant in the control of the tube grid. This time constant should be considerably less than 5 seconds (the time of each carrier interruption preceding the CONELRAD alert message) but may be of a length sufficient to prevent the alarm from tripping on momentary carrier interruptions occurring during transmitter overloads, corona discharges from antenna towers, antenna pattern changeovers, etc. The tube used as a control tube for the relay RL_1 is a pentode having a sharp cutoff characteristic, a high transconductance, and a high allowable plate dissipation. Of the three types tested in the circuit (*6BH6*, *6AG5*, and *6AH6*) the *6AH6* seemed to give the best performance. However, all three are directly interchangeable and any one gave satisfactory results with only a slight bias adjustment required. A fixed bias is applied to the cathode of the control tube to the extent barely necessary for cutoff in the absence of any bias on the grid. This fixed bias is obtained by the adjustment of a wire-wound potentiometer R_6 in series with a 40,000-ohm resistor R_5 across the B+ supply. This bias adjustment proved to be the only critical adjustment required in the alarm device and, once established for the type control tube used, the setting should not be disturbed. The positive bias developed by rectifying the i-f voltage produced in the receiver by an incoming signal is applied to the grid of the control tube in such an amount as to overcome the fixed bias and hold the tube in a conducting state. This draws plate current through the coil of the plate circuit relay RL_1 and causes it to be held up. The 110-volt relay RL_2 is not activated and the alarm will indicate normal operation or "safe." The green indicator light LM_2 will be on; the red light LM_1 will be off; the electric clock will be running; and the audio output of the receiver will be fed into the amber light LM_3 causing it to flicker with the modulation.

When the signal into the receiver is interrupted, the receiver i-f voltage almost disappears. The positive bias obtained by rectifying part of this voltage is removed from the grid of the control tube; the fixed bias becomes dominant and cuts the tube off. The plate circuit relay RL_1 will then drop out feeding 110 volts a-c to the coil of relay RL_2 causing that relay to pull up and electrically latch in this position. The green light goes off; the red light comes on; the electric clock stops; a remote buzzer or bell, if used, will be sounded; and the audio output of the receiver will be fed into the loudspeaker. If the signal again appears at the receiver input, the positive bias returns to the grid of the control tube and it again conducts. This will pull the plate circuit relay up and turn on the green light. The 110-volt relay RL_2 remains latched up with the consequent indications until reset by momentarily interrupting its coil supply voltage by depressing the "RESET" switch S_2. If no signal is available at the receiver input, the plate circuit relay will not pull up, the green light will not turn on, and the alarm cannot be reset.

ALARM OR RECEIVER FAILURE WILL BE INDICATED

Any failure of the alarm or the associated receiver results in a positive alarm indication. Because the rectified i-f voltage is used for control purposes, a reasonable amount of signal fading can be tolerated provided the "THRESHOLD" control R_1 is adjusted just below the maximum fade expected. Momentary noise pulses have no effect on the alarm. The characteristics inherent in a pentode control tube allow severe power-supply voltage fluctuations without adverse effect. A fairly sensitive plate circuit relay RL_1 must be used, but a Potter Brumfield, Type *LM-5,* relay costing less than $3.00 was found to be adequate. The fuse F_1 may be eliminated. Its function is to prohibit excessive plate current in the control tube. This condition might be caused by maladjustment of the cathode bias control R_6 resulting in insufficient fixed bias accompanied by an improper adjustment of the "THRESHOLD" control R_1. The fuse will open with a prolonged current of about 13 milliamperes.

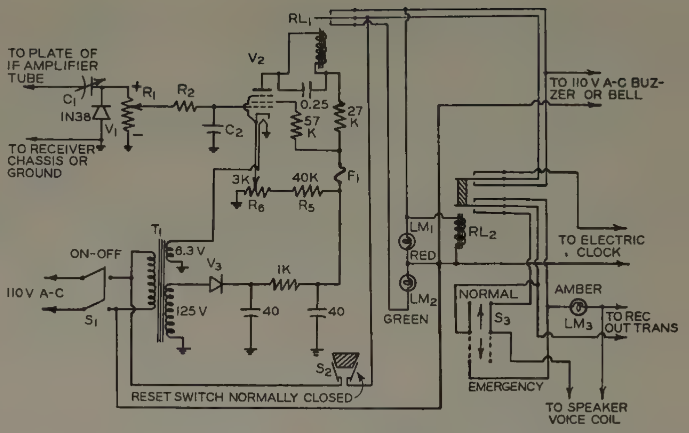


Fig. 2. Circuit of the CONELRAD carrier interruption automatic alarm

EMERGENCY PROVISION OF ALARM DEVICE

If the alarm fails or the signal becomes so weak that the alarm cannot be set, aural monitoring may be used. If aural monitoring is impractical, the switch S_3 may be placed in the "emergency" position. In this position, even though the device is in "alarm" with the red light on, the receiver output is fed into LM_3, a type *47* dial light. Observation of the flickering of this dial light will enable an operator to determine whether or not modulation is being received. Any prolonged absence of this modulation indication would be investigated by placing switch S_3 in the "normal" position for an aural check.

The components for this alarm device cost less than $35.00 and may be mounted in a metal cabinet measuring 6 by 6 by 6 inches. All the switches and the indicating lights can be mounted in this cabinet or can be remotely positioned for convenience. This alarm device is suitable for use in conjunction with any good broadcast receiver. When used with a Hallicrafters *SX 24* receiver it operated on a signal plus noise level of *S* $3^1/_2$ when the average noise level alone was *S* 2 with occasional pulses to *S* 6 or 7 as shown on the *S* meter with the r-f gain control fully advanced. A signal-to-noise ratio such as this makes aural monitoring very difficult.

Network Analyzer

A large capacity network analyzer has been installed at Syracuse University through the cooperation of Niagara Mohawk Power Corporation, New York State Electric and Gas Corporation, and General Electric Company. It was designed for use in the accurate and convenient study of power transmission and distribution system problems.

The analyzer, 66 feet long and 7 feet high, consists of 2 instrument and control cabinets, 16 generator units, 125 line units, 75 equivalent pi-line units, 64 adjustable voltage load units, and 50 mutual transformer units.

TEN FOUNDING FATHERS OF THE ELECTRICAL SCIENCE

VIII. MICHAEL FARADAY

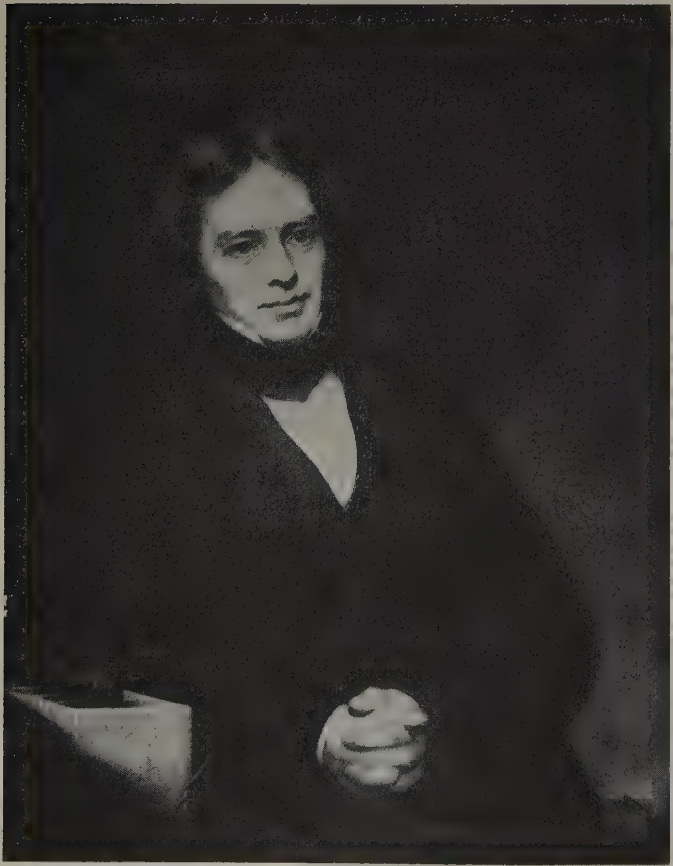
and the discovery of electromagnetic induction

BERN DIBNER
FELLOW AIEE

Michael Faraday was a chemist and electrical experimenter who discovered electromagnetic induction, the laws of electrolytic action and magnetic rotation. His discoveries led directly to large-scale electrification and electric controls in industry.

TWO STEPS advanced electrical science to the status of a major social force. The first was the invention by Alessandro Volta of a chemical source of electricity, the voltaic cell, and the second the discovery of electromagnetic induction by Faraday. Volta's battery provided early electricians with means for electrically decomposing elements, producing an electric arc, and more important, it led to the construction of the electromagnet which, in turn, opened the way to the full expansion of the electrical age.

The early investigators asked themselves why powerful magnets could be produced by the flow of an electric current in a wire, yet electricity could not be produced from a magnetic circuit. The problem set off many experiments in the first third of the 1800's. It remained for Michael Faraday to resolve this problem and thereby to transform the fabric of society into an ever-growing integrated network.



From a painting by Thomas Phillips

Michael Faraday

Of most humble origin, and with no formal education, Faraday began work at the Royal Institution in London as a laboratory assistant to Humphry Davy, an outstanding chemist and electrical experimenter of the time. Through Davy, Faraday met the important scientists of England and the Continent including Ampere, Count Rumford, and Volta. At the Royal Institution Faraday lived and experimented in chemistry and in electricity. A series of lectures and demonstrations before distinguished audiences, including royalty, brought the work of these experimenters before the rapidly expanding world of science.

Faraday's electrical experiments began to receive attention in 1821 when he demonstrated electromagnetic rotation, in which the flow of electric current caused a magnet to revolve around a wire carrying current or a wire carrying current to revolve around a fixed magnet. The motions continued as long as the current continued to flow. He then succeeded in causing a delicately balanced wire carrying current to move as a result of being in the earth's magnetic field alone. For 10 years thereafter, Faraday concerned himself with the problem of converting magnetic force into some form of electric force. He studied intensely what other experimenters had accomplished and, in particular, the phenomenon of electrostatic induction. Four times in these 10 years Faraday had applied himself to the specific investigation of magnetoelectric generation, with no results.

In the summer of 1831 he began a fifth attempt at solving the problem. He took a soft iron ring about 6 inches in diameter and wound a coil of copper wire on one side of the ring and a second coil on the other side. He next placed a magnetic needle a short distance from the ring and connected it to the first coil; a battery was connected to the second coil. At the instant of connection the magnetic needle moved and came to rest; when the connection was

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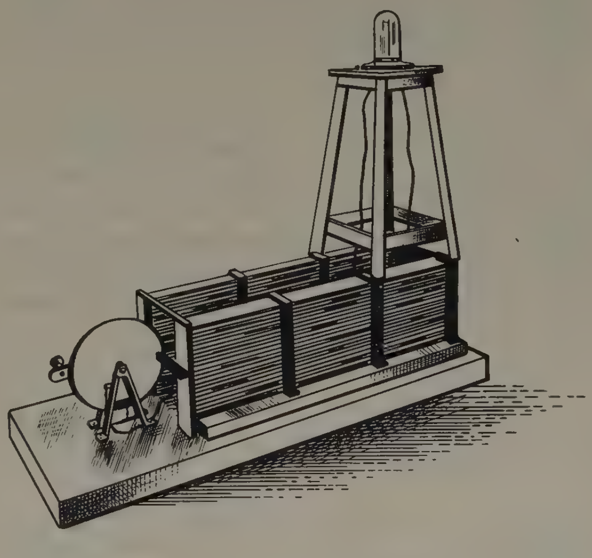
broken the motion was repeated in the opposite direction. He checked the true *magnetic* nature of the current produced by substituting a copper ring for the iron one and observed little motion. Faraday then wound a coil of 220 feet of wire into a solenoid and connected its ends to a galvanometer. When he plunged a cylindrical bar magnet into the coil, the needle moved; when he pulled it out, it moved in the opposite direction. He therefore concluded that it was the *relative* motion of magnet and coil that was inducing the generation of electric current.

Following the cue established by the momentary generation of an electric impulse from a magnetic source, on October 28, 1831, Faraday completed the assembly of an electric machine consisting of the great magnet of the Royal Society between the poles of which he had erected a copper disk 12 inches in diameter on an axle terminating in a crank. From the disk two collector strips were carried; one rode on the axle, the other on the rim of the disk, and these strips were led to a galvanometer. The axle and disk rim where the strips made contact were treated with amalgam. When Faraday revolved the disk by means of an attached handle the galvanometer showed a deflection; when he reversed the rotation the deflection was in the opposite direction. Faraday visualized his disk "cutting" magnetic lines flowing from pole to pole of the great magnet. These lines he could demonstrate by sprinkling iron filings in the path between pole and pole. When he replaced the disk by a wire that he moved across the magnetic field, the same results followed.



The generator with which Faraday converted magnetism into electricity

He devoted 10 days of intensive experimentation to check the nature of the electricity so produced and finally, at the end of November, announced his most important discovery before the Royal Society. Electricity finally had been produced from magnetism. This discovery was formulated into a paper for publication under the title "Experimental Researches in Electricity" and was the first of a series of 29 that continued on through 1852, announcing the many contributions of Faraday to the science he helped establish.

After Faraday's major contribution there came the discovery of self-induced currents, polarity in diamagnetic bodies, lines and fields of magnetic force, and the use of induced current as a measure of field intensity. In the work of his earlier interest, chemistry, he evolved the law of electrochemical decomposition, electrochemical conduction, analysis of generation in the voltaic pile, and the general theory of electrolysis. With his discoveries Faraday contributed a parallel vocabulary of new electrical and magnetic terms that have become the language of the science. His work carried him into a study of dielectrics and the determination of "specific inductive capacity." It was no easy step between the invention of the electric generator by the process of induction (which constitutes the practical form of the electric generators of today) and its practical use in industry. Devices to *use* this electricity still had to be invented. The electric light, the electric motor, metallurgical, thermal, or chemical use of electricity, these and similar devices awaited the inventive genius of later electricians. Other than its application to telegraphy it was not until 1860 that current from an electric generator was applied to lighthouse illumination thereby providing the first bulk use of the new force. However, from then on the science moved with increasing rapidity so that by the end of the century, in England alone, investments in electric equipment exceeded £100,000,000, a pyramid built up in less than 70 years.

Following the announcement of his discovery of the means for generating electricity by electromagnetic induction, in a paper read before the Royal Society on November 24, 1831, and in a letter to his friend Richard Phillips written from Brighton on November 25, the recognition of the importance of the discovery by scientists was immediate. Over a hundred academic and scientific honors were conferred upon Faraday, including the only one which he actively sought, membership in the Royal Society. Sponsored by Phillips, Faraday at the age of 32 became a Fellow of the Royal Society in January 1824. Appointed director of the laboratory of the Royal Institution in 1825, he became, 8 years later, professor of chemistry there for life. Although he was without the obligation to lecture, his lectures there became exceedingly popular. He remained at the Institution for 54 years and died in 1867.

In the 54 fruitful years he spent as experimenter and lecturer at the Royal Institution, Faraday had published 158 papers in chemistry and electricity. The most important of these was the series "Experimental Researches in Electricity" which continued to appear for a period of over 20 years. In the first of these, as he indicated in his announcement to Phillips, the title was established and the subjects treated were to be "I. On the induction of electric currents. II. On the evolution of Electricity from magnetism. III. On a New electrical condition of matter. IV. On Arago's magnetic phenomena. There is a bill of fare for you—." In January 1832 the first of these papers was published and in that year Oxford conferred an honorary doctorate on Faraday. A grateful International Electrical Congress, meeting in Paris in 1891, voted to term the electrical unit of capacitance the "farad" in honor of one who had contributed so much to electrical science.

Economics of Location of Control Devices on Machine Tools

DICKEY DYER   W. H. COMPTON

The human factors that should be taken into consideration in designing machines are summarized and a method of applying established timestudy constants for the various body movements required in machine operation is considered.

PROPER arrangement of controls and meters is most essential in order fully to utilize the human efficiency of the machine-tool-setup man, operator, maintenance electrician, or mechanic. Therefore, it is the purpose of this article to summarize the human factors that should be considered in the design of machines. These factors will be followed by a method of applying established timestudy constants for the various body movements required in the operation of a machine. From these factors based in units of ten-thousandths of a minute it is possible to establish operating times for various control locations. These findings changed to dollars and cents will help determine the value of the many control arrangements which are available during the design of the machine. Most of this material will not be new, but it might help to substantiate present opinions with actual facts.

Although the amount of present material on the design aspects of machine tools is very voluminous, the subject of the combination of man and his machine has been neglected. One of the first studies of human motions was made by the Royal Engineering Society of London in 1872. This work of over a thousand photographs of the nude human male and female in various stages of performing work was printed in seven editions. The last one was printed in 1902.

This volume has been followed by several others of recent publication which are of much more practical use to the machine-tool designer. Recent studies have been made by Air and Submarine Units of the Armed Services during World War II. These studies were performed when it was found that the engineered products had passed the ability of man to control them properly. Too many instruments competed for the operator's time. Many controls had to be placed at the operator's fingertips. These findings are quite comprehensive and are very helpful in determining what is convenient to the human being. Studies were performed for military vehicles where cost of construction is secondary to factors which are not major in machine-tool design yet none of the published material compared the savings with the added cost of convenience of operation.

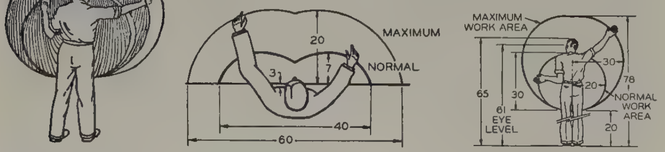


Fig. 1 (left). Normal and maximum working areas in three dimensions indicate semicircular range of arms and hands. Fig. 2 (center). Width and depth of normal and maximum working areas in horizontal plane. Dimensions indicate location of area that can be reached without body movements. Fig. 3 (right). Width and height of normal and maximum working areas in the vertical plane

Considering the layout of the machine tool for the best man-machine combination, six factors are to be considered:

1. All controls and meters should be located within a practical working distance from the operator.
2. Within the practical working distance each control and meter should be located in the position where it may be most efficiently used.
3. Where two or more controls or meters have the same optimal position, the most important and most frequently used items should be given the preferred positions.
4. Controls and meters should be grouped in patterns that make for the easiest operation and observation from the point of view of the operator.
5. Other parts of the body should be utilized when the hands are overloaded.
6. Any possible confusion of controls or meters by the operator should be avoided by proper design or placement.

The placement of the operator in a position to reach each control properly, to load and unload parts, and properly view the meters at the same time is not simple. This same problem exists for the maintenance crew which is servicing a large electric or hydraulic control panel for an automation line, where a few minutes of down time is a considerable loss.

One method of determining the reach of the human to be considered is to use the data on body sizes collected in various anthropological studies. Fig. 1 illustrates the normal and maximum working space in three dimensions of the human who is standing. This same area is also available to one who is sitting. Fig. 2 is a view of the available reach of most human beings in the horizontal plane. Here the semicircular arcs of the maximum and normal working

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Revised text of a paper presented at the AIEE Conference on Machine Tools, October 14–16, 1953, Cleveland, Ohio, and recommended for publication by the AIEE Subcommittee on Machine Tools.

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areas are most clearly defined. These areas are for an operator who is standing in a fixed position without moving his trunk. Dimensions shown are based on minimum instead of average, in order to accommodate 95 to 97 per cent of all humans.

Man is more than just hands, fingers, and arms. He also has a trunk, knees, legs, and feet to operate controls. Locations of these are shown in Fig. 3, where range of the normal and maximum working areas is shown for the vertical plane.

The location of the knee is about 13 inches from the floor, pivoted at the hip, which is 32 inches high. If the operator is located on a seat 30 inches high, he can operate in the same range as an individual who is standing on his feet. In this particular case it is well to provide a footrest. When the operator is sitting, part of the working area is eliminated by the knees.

Chairs which are well designed for sitting comfort and are easily adjusted for the operator to work in the same area whether seated or standing are on the market. The chair illustrated in Fig. 4 has an adjustable seat height, back, and footrest. The seat tilts forward in order that the operator can easily slip to a standing position.

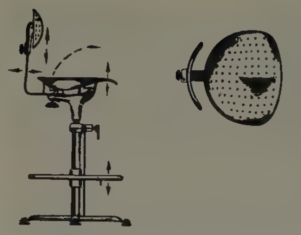
In order to determine the best location of visual indicators, the ability of the eyes must be considered. Under the most extreme conditions of head and eye movement, with the body fixed in position, the average operator can fixate his eyes from 90° above to about 90° below the horizontal, and at least 90° to either side. Unlimited head and body movement will permit vision in almost any angle. When the eyes are fixed on any one point, only a small area within $1^1/_2$° of the point of fixation is in clear focus. The area that is only 5° from the point of fixation is only one half as good. The remaining surrounding area is divided into two fields, which are the binocular vision and the monocular vision shown in Fig. 5. In order for a signal to be seen, it must be within the total range of these fields.

To determine the best location for one particular meter, first it must be determined where an operator's visual point of fixation will be at the time that he requires metered information. Load meters for each milling head of large planer millers are usually at the point of work. There is no question that a large milling machine requires a pendant station, but usually there is a question regarding smaller machines. What functions are to be provided, such as remote controlled variable speed, are also a question that could be solved more easily with the proper use of established timestudy constants coupled with past experience.

Time does not permit the discussion of the amount and location of light or noise levels. It goes without saying that safety to the human is the first consideration, and only the lack of time has also limited this phase of the subject.

Meter location has been discussed as to visual range, but there is considerable material available as to design of meters depending on the operator's required accuracy of response and precision. Sources of information regarding this and other aspects of this subject are included in the bibliography.

Thus far, the location of control devices within the normal working range of the average human being has been considered. The development of these devices falls to the creative ability of the electrical, mechanical, or possibly chemical engineer. The evaluation of the dollars and cents significance of these devices falls to the evaluative ability of the industrial engineer.



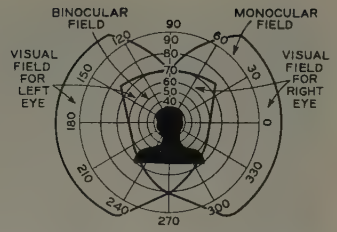


Fig. 4 (left). Factory chair with arrows denoting available adjustments. Fig. 5 (right). Visual field for two eyes, showing the total range of both eyes and binocular vision when fields of both eyes overlap

A body of data has been developed in the industrial engineering field which determines, in time, the capabilities and limitations of the human body at work. These data are similar to the data with which the electrical or the mechanical engineer is accustomed to dealing in connection with such subjects as operation of electric circuits, relative strength of various materials, etc., in that they are controlled by quantitative criteria and thereby afford the opportunity for various engineers to reproduce each other's findings. By determining the physical limitations and physical characteristics of the work place in measurements such as inches, pounds, and degrees, it is possible with these industrial engineering data to determine during the design period the time it will take properly motivated operators to use contemplated control devices in comparison with existing, or alternative contemplated, control devices.

By the very nature of their subject these data were originally empirical, but after some initial revision based on application experience, these data have subsequently been verified over some 3,000,000,000 man-hours of application here and abroad and now compare favorably in validity with data used in electrical and mechanical engineering. Because of the quantitative criteria used to control application of the data, industrial engineers throughout the world now arrive at common answers in utilizing the data.

By way of example of this, visualize the 1/2-inch machine bolt which must be inserted in a 17/32-inch bolt-hole in a machine tool assembly, see Table I.

The bolt-hole is the "target" and its diameter falls within the range of the third horizontal line. The bolt itself is the "plug" and its ratio with the "target" falls within the range

Table I. Extract from *Work-Factor* Assembly Tables

Target Diameter	Closed Targets			
	Ratio of Plug Dia. ÷ Target Dia.			
	To 0.224	0.225 to 0.289	0.900 to 0.934	0.935 to 1.000
0.875 inch and up	18	18	51	59
0.625 to 0.874 inch	18	18	51	59
0.375 to 0.624 inch	18	18	57	65
0.225 to 0.374 inch	31	44	83	91
0.175 to 0.224 inch	44	44	83	91
0.125 to 0.174 inch	44	51	83	91
0.075 to 0.124 inch	83	83	109	117
0.025 to 0.074 inch	96	96	122	130

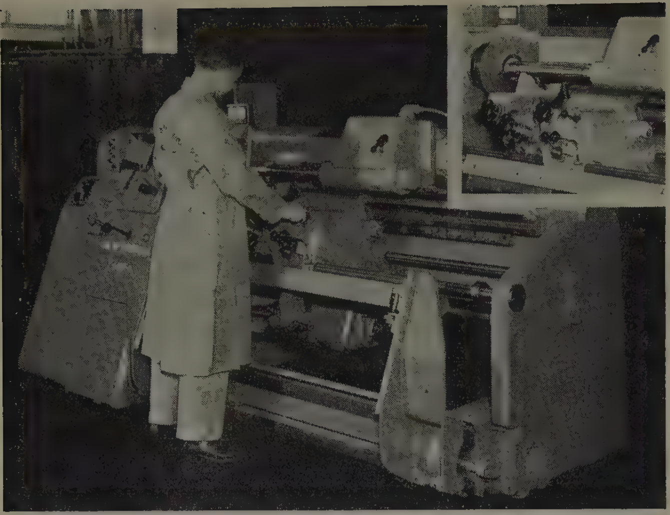


Fig. 6. A copying lathe of modern design which gives consideration to the human factors thus permitting greater output and better quality yet less operator fatigue. The inset shows the controls obscured by the operator

of the right-most vertical column. The time to assemble the bolt to the bolt-hole is therefore "59" or 0.0059 minute. The timestandard refers only to assembly, not to getting the bolt to the hole or sliding it into the hole after assembly. Additional timestandards are set from other parts of the tables for these elements.

These other timestandards come from other tables such as that shown in Table II.

Note across the top of the table the term "Work Factors." These Work Factors are representative of degrees of difficulty which must be overcome by the operator in performing motions over various distances. To identify Work Factors, the designer must determine whether certain measurements are present in the work place which call for the use of Work Factors. To recognize these Work Factors, the designer is trained in the use of a very precise set of rules and theorems which tell him how to take the measurements and how to apply the Work Factors.

Three *Work-Factor* Rules of Application, which illustrate the precision with which the application procedure has been developed are

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Extracts from *Work-Factor* Manual

A Rule of Application for Transport
Rule 14.0. If a body member is required to pass within 1 inch of an object which can cause injury, a Precaution Work Factor is required.

A Rule of Application for Assemble
Rule 25.0. An upright motion will always be allowed following Alignment where the Plug—Target Ratio is 0.90 or greater.

A Rule of Application for Reaction
Rule 46.0. Multiple choice decisions, in which more than two alternate actions are possible, require one React-for-Decision time.

It will have been noted in connection with Table II that the farther the arm must move, the more time it must take. In addition to that, different body members take different times to move. Table III assembles for comparative purposes extracts from various *Work-Factor* Body Member Tables to give an idea of the differences in time involved. "Two Work Factor" motions are used for this purpose because they are fairly common ones.

By the use of the time values contained on complete *Work-Factor* Moving Time Table according to the Rules of Application governing them as found in The *Work-Factor* Manual, it is entirely practical to evaluate the economics of placing machine-tool controls within the normal working area as described and covered in Figs. 1 through 3. Since timestandards can be developed for use of controls as they are presently placed, and these can be compared with timestandards developed for use of controls as it is visualized they might be placed within the normal working area. The differences in timestandards for use of controls placed at the point of machine action and placed within the normal working area can be established from these two prior determinations, and then the dollar savings in operation of the tool can be determined by pricing out this difference at prevailing wage rates and multiplying the answer by anticipated frequency of use of the controls.

Fig. 6 shows a copying lathe created in Switzerland and now being manufactured by New Britain Machine Company. All working controls except for spindle speed change gears are located on the tool carriage within 26 inches on the horizontal plane and 6 inches on the vertical plane, which is well within the normal working area specified above and in Figs. 1 through 3. Moreover, the horizontal center line of these controls is 33 inches from the floor and 12 inches from the operator's body which is at the outer range of the normal working area and comfortably within the maximum working area.

On the carriage from right to left are a carriage clutch and brake for horizontal traverse, and beside it a lever for feed selection. Above them is a lever for normal, slow, and rapid horizontal traverse. Next to the left is a hand wheel for setting depth of cut and a lever for rapid tool vertical approach to the work. Above them is a hand wheel for hand travel horizontally. Next to the left is a hand wheel for adjustment of the tool carriage to the copying slide. On the head stock are three spindle speed selection levers which are conventional in type. Across the entire front of the machine, $3^1/_2$ inches from the floor, is a bar which acts as a switch for moving the tailstock to and from the work.

Now how should such a machine at the stage where it was only a visualization in the designer's eye be evaluated, considering only the control features and ignoring the factors of additional rigidity which happen to be built into this machine because of the vertical position of the tool carriage? These factors have a very important effect on the speeds and feeds which this machine can stand, but they are not the concern of this article which deals solely with control devices.

There is an existing machine tool which is being redesigned. This tool will remain nameless for obvious reasons. However, its dimensional characteristics will be used for comparison purposes. Of course, a part to be turned has to be assumed. In this instance it will be a forging 12 inches long with 4 diameters each sized in one cut. Only work elements affected by control device locations and the mechanisms activated thereby will be analyzed. It will

Table II. Extract from *Work-Factor* Arm Tables

ARM—Measured at Knuckles					
Distance Moved	Basic	Work Factors 1	2	3	4
1 inch	18	26	34	40	46
2 inches	20	29	37	44	50
3 inches	22	32	41	50	57
4 inches	26	38	48	58	66
5 inches	29	43	55	65	75
12 inches	46	65	85	102	117
13 inches	47	67	88	105	121
14 inches	49	69	90	109	125
15 inches	51	71	92	113	129
35 inches	76	103	128	151	171
40 inches	81	109	135	159	179

Table III. Extract from *Work-Factor* Body Member Movements Tables

Distance Moved	Two Work Factors				
	Finger	Arm	Trunk	Leg	Foot
1 inch	29	34	49	39	37
2 inches	32	37	53	42	40
3 inches	36	41	60	48	45
4 inches	42	48	70	55	53
5 inches		55	79	63	
12 inches		85	123	97	
13 inches		88	127	101	
14 inches		90	130	103	
15 inches		92	133	106	
35 inches		128		147	
40 inches		135		155	

Table IV. "Nameless" Machine

Left Hand			Cumulative Time		Right Hand		
Elemental Description	Analysis	Time	LH	RH	Time	Analysis	Elemental Description
Reach to turned part	A18D	76	76	83	83	A22D	Reach to tailstock wheel handle
Grasp part	F2WW	32	108	112	29	F1WW	Grasp handle
				486	374	4A16WW	Turn handle 4 times (5-in. diam.)
				509	23	F1W	Release handle
				589	80	A20D	Reach to turned part
Hold part against head center	BD	513	621	621	32	F2WW	Grasp part
Release part	F2W	25	646				
Slide hand to left	A6D	47	693				
Grasp part	F2W	25	718	718	97	BD	Hold part against head center
Move part from head center	A1WD	34	752	752	34	A1WD	Move part from head center
Move part to position for disposal	A12W	65	817	817	65	A12W	Move part to position for disposal
Move unturned part to head center	A18WSD	120	937	937	120	A18WSD	Move unturned part to head center
Assemble part to head center	T = $^3/_8$ inch; R = 0.200	18	955	955	18	T = $^3/_8$ inch; R = 0.200	Assemble part to head center
Release part	F2W	25	980				
Slide hand to right	A6D	47	1,027				
Grasp part	F2WW	32	1,059	1,059	104	BD	Hold part against head center
				1,034	25	F2W	Release part
				1,164	80	A20D	Reach to tailstock wheel handle
Hold part	BD	452	1,511	1,193	29	F1WW	Grasp handle
Guide part to tail center	A1WSD	40	1,551	1,522	329	$3^1/_2$A16WW	Turn handle $3^1/_2$ times (5-in. diam.)
Assemble part to tail center	T = $^3/_8$ inch; R = 0.200	18	1,569	1,569	47	$^1/_2$A16WW	Turn handle $^1/_2$ time
Hold part for tension	BD	12	1,581	1,583	14	$^1/_8$A16WWW	Turn handle back for tension
Release part	F2W	25	1,606	1,606	23	F1W	Release handle

Table V. New Britain Machine

Left Foot			Left Hand			Cumulative Time			Right Hand		
Element	Analysis	Time	Element	Analysis	Time	LF	LH	RH	Time	Analysis	Element
			Reach to turned part	A12D	65		65	65	65	A12D	Reach to tailstock selector switch handle
			Grasp part	F2WW	32		87	81	16	F1	Grasp handle
Lift foot to tailstock switch foot-bar	FT4D	41				103		103	22	A3	Pull handle to "Out"
Push bar	FT2W	32				135		135	32	BD	Hold handle
Lift foot to clear bar	FT2	22				157		225	90	MT	Wait for tail center to clear
Drop foot to floor	FT4	29				186		247	22	A3	Push handle to "In"
								263	16	F1	Release handle
								336	73	A16D	Reach to turned part
			Hold part against head center	BD	281		368	368	32	F2WW	Grasp turned part
			Release part	F2WW	32		400				
			Slide hand to left	A6D	47		447				
			Grasp part	F2W	25		472	472	104	BD	Hold part against head center
			Move part from head center	A1WD	34		506	506	34	A1WD	Move part from head center
			Move part to position for disposal	A12W	65		571	571	65	A12W	Move part to position for disposal
			Move unturned part to head center	A12WSD	102		673	673	102	A12WSD	Move unturned part to head center
Lift foot to tailstock switch foot-bar	FT4D	41	Assemble part to head center	T = $^3/_8$ inch; R = 0.200	18	691	691	691	18	T = $^3/_8$ inch; R = 0.200	Assemble part to head center
Push bar	FT2W	32	Hold part	BD		723	723	723		BD	Hold part
Lift foot to clear bar	FT2	22	Wait for tail center to engage	MT	90	745	813	813	90	MT	Wait for tail center to engage
Drop foot to floor	FT4	29	(Guide part to tail center)	(A1WSD)	(40)	774			(40)	(A1WSD)	(Guide part to tail center)
			(Assemble part to tail center)	(T = $^3/_8$ inch; R = 0.200)	(18)				(18)	(T = $^3/_8$ inch; R = 0.200)	(Assemble part to tail center)
			Release part	F2W	25		838	838	25	F2W	Release part

Table VI. Savings Figured on an Annual Basis

$$0.0768\ \text{“Select Time” Saved/Piece} \times 1.45\ \text{Normalizing Factor} = 0.1114\ \text{Operating Time Saved/Piece}$$

$$0.1114\ \text{Operating Time Saved/Piece} \times \frac{(\$1.90\ \text{Wage/Hour} + 250\%\ \text{Overhead Rate})}{60\ \text{Minutes/Hour}} = 1\tfrac{3}{10}\text{¢ Saved/Piece}$$

$$\frac{8\ \text{Hours/Shift} \times 60\ \text{Minutes/Hour}}{3.4\ \text{Cycle Time/Piece}} = 141\ \text{Pieces/Day}$$

$$141\ \text{Pieces/Day} \times 5\ \text{Days/Week} \times 50\ \text{Weeks/Year} = 35{,}250\ \text{Pieces/Year}$$

$$35{,}250\ \text{Pieces/Year} \times 1\tfrac{3}{10}\text{¢ Saved/Piece} = \$458.25\ \text{Saved/Year}$$

be assumed that the cycle time on the “Nameless” machine is 3.4 minutes and that the speeds and feeds that are used on the machine and the New Britain machine are identical, even though it is known that the greater rigidity of the tool carriage on the New Britain machine will permit greater feeds and speeds. Time does not permit analysis of all the innovations on the New Britain machine, so only part unloading and loading will be analyzed, since these work elements illustrate several interesting points.

Table IV is an analysis of part unloading and loading on the “Nameless” machine and Table V is an analysis of part unloading and loading on the New Britain machine. *Work-Factor* “Select Time” for that part of the unloading and loading cycle which is different between the two machines is 0.1606 and 0.0838 minute for the “Nameless” and the New Britain machine, respectively. This difference is occasioned by several features. Firstly, the tool carriage moves in the vertical plane rather than the horizontal plane, such that the distance from the operator to the spindle is appreciably reduced. Secondly, the tail center is hydraulically actuated which offers a substantial reduction in time consumed over that involved when the tail center is moved in and out with a handwheel. Thirdly, several motions are eliminated in the hands since both hands can remain on the piece while the tail center is started in and out by a switch activated by the foot.

The saving in “Select Time” is therefore 0.0768 minute. To convert this time to normal operating time, a company might add to it a normalizing factor of 25 per cent and allowances for *P*, *F* and *D*—personal, fatigue, and delay—of 20 per cent. This converts the time to 0.1114 minute. To calculate the saving secured by this time, it must be priced out at the prevailing wage rate for copying lathe operators, plus factory overhead, and must then be multiplied by estimated frequency of occurrence. Table VI makes this calculation on an annual basis. It will be noted that the saving amounts to some $460 per annum.

As a determination of this kind is made, the designer can compare the cost of making the change in design with the saving to be made by the purchaser of the machine. He can then evaluate whether the saving is sufficiently attractive to make it worth while for the purchaser of the machine to pay the additional price, which will be necessitated by the increased manufacturing cost of incorporating the new feature on the machine. Of course, there are other savings to be made from other features of the New Britain machine but, as previously stated, space does not permit covering them.

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* Reprints are available from The Work-Factor Company, 4465 Silsby Road, Cleveland 18, Ohio.

Servicing Center for Short-Haul Carrier Systems

A. L. BONNER

ONE OF THE principal advantages of the plug-in feature of *N*[1], *O*[2], and *ON*[3] carrier system equipment is that it facilitates the normal maintenance of the systems. Thus units, which develop trouble that cannot be readily cleared on the job, may be sent to a servicing center.

A principal requirement of a servicing center is that it be capable of setting up test conditions quickly and easily so that the tester can concentrate on the trouble to be cleared.

Fig. 1 shows an arrangement of a complete servicing center designed for testing *N*, *O*, and *ON* carrier units. Its principal components consist of a servicing center test set and associated variable-frequency oscillator and vacuum-tube voltmeter. The oscilloscope is particularly valuable in locating trouble in signaling circuits. The frequency counter is essential where crystal oscillator frequencies are to be checked. An *O* carrier twin-channel unit is shown held by an adjustable clamp, and connected to the test set by a test cord.

The servicing center test set includes two nearly independent switching circuits and built-in testing equipment consisting of a loop-back amplifier, signaling circuit test equipment, and a crystal oscillator.

Fig. 2 shows the test set chassis removed from its cabinet and turned on its side. The top shelf is swung open to make the rotary switches *A*, *B*, *C*, and *D* accessible. The built-in test equipment is located on this shelf.

Switches *A* and *B* set up 36 different test conditions for *N*, *O*, and *ON* carrier channel units and their subassemblies. They connect the built-in and external test equipment as required for the particular unit under test. Switches *C* and *D* set up about 60 different test conditions for the *N*, *O*, and *ON* group, repeater, oscillator, and filter units.

A major design problem was involved in reducing the coupling between the low-level input leads and the high-level output leads of the switching circuits. Since coaxial wire is used and the conductor only is switched, the coaxial shields are connected together by permanent ties in order to complete the ground return paths. This is complicated because the different carrier units utilize the jack terminals in different ways so that a conductor and its associated ground return paths may be in the high-level part of the switching system in one test, and the low level in another. The problem was solved by tying each end of each coaxial shield to a centrally located low-impedance common ground point. In this way a ground return path around each switch point is always provided and the common impedance between the high- and low-level circuits is kept low. As the ground leads carry most of the return current and lie close together, they are shielded to reduce crosstalk.

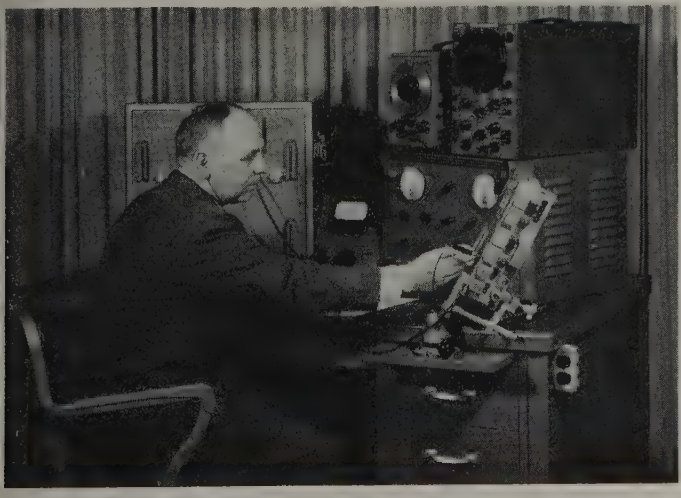

Fig. 1. An arrangement for a complete servicing center

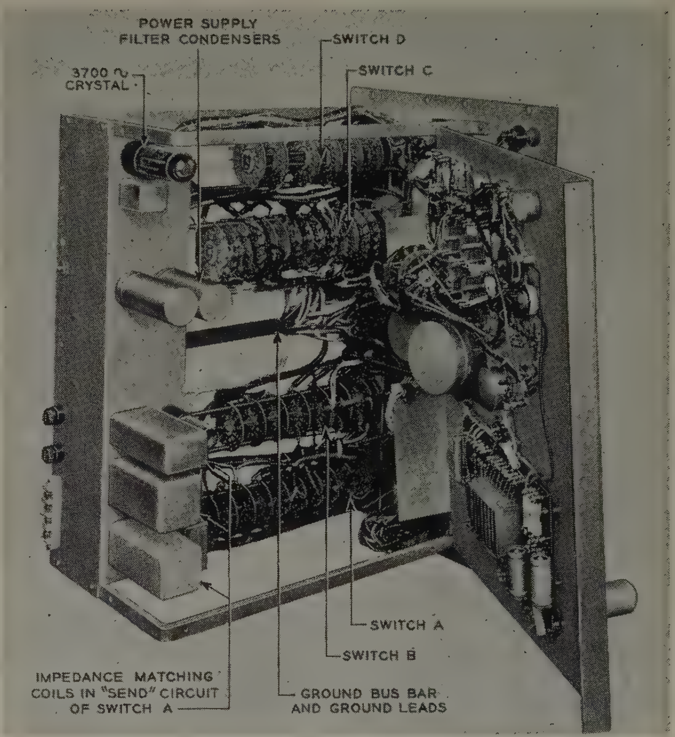
POWER SUPPLY FILTER CONDENSERS
SWITCH D
3700 ~ CRYSTAL
SWITCH C
SWITCH A
SWITCH B
IMPEDANCE MATCHING COILS IN "SEND" CIRCUIT OF SWITCH A
GROUND BUS BAR AND GROUND LEADS

Fig. 2. Test set chassis with top shelf swung open

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Series- vs. Parallel-Connected Ship Generators

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WHEN A NUMBER of d-c diesel-driven generators are used to supply propulsion power to a motor driving a ship's propeller, the generators usually are connected in series. The series system has many advantages and in most cases is the proper selection. However, there are applications where the advantages obtained by the use of parallel-connected generators more than offset the problems encountered in the use of this system. Therefore unless the answer is obvious, it is wise to study the particular system involved before making a final decision with regard to series or parallel connection of the generators.

With series-connected generators, a reduction in number of engines in use results in a reduction in motor voltage and proportional reduction in motor speed. Since propeller horsepower varies approximately as the speed cubed, the motor field can be weakened until the motor returns to a speed which will absorb the engine horsepower available.

With parallel-connected generators, a reduction in number of engines in use does not reduce the voltage. The motor will attempt to run at full speed and overload the engines in use. As far as motor capacity permits, the motor field can be strengthened to slow down the motor, beyond this point the generator voltage must be reduced.

Generator voltage can be reduced in one of two ways, either by reducing engine speed or decreasing generator field flux. When engine speed is reduced, the engine no longer can supply rated output. When generator voltage is reduced by decreasing field flux, the generator can produce full-rated output only by an increase in current proportional to the reduction in voltage. Moderate generator current overloads in the order of 20 per cent usually can be tolerated for short periods of time provided they are applied rarely.

The series circuit offers several advantages, among which are: 1. up to a limiting value of motor field weakening, it is possible to utilize full rated horsepower of all available engines regardless of the number of engines in operation; 2. load division between the engines is satisfactory regardless of minor differences in engine speeds or generator voltages.

In the case of a diesel-electric ship requiring considerable horsepower, it is common practice to use a number of relatively high-speed diesel-generator sets driving a single motor. This results in relatively low voltage for each generator if the series circuit is used. Low voltage means high generator current, a large commutator, and maximum number of brushes. It may even result in a larger diameter generator frame to accommodate the larger commutator. More and higher rated setup switch contacts are required for the series circuit.

By making a study similar to that shown in Fig. 1, it is possible to analyze the relative merits of series versus parallel connection of the generators and arrive at the best over-all proposition. Such a study is worth while for vessels requiring above 2,000 shaft horsepower in a single armature motor and utilizing three or more engine generator sets.

%	% BASE RPM			% GENERATOR FIELD FLUX			% GENERATOR VOLTS			% GENERATOR CURRENT			% MOTOR FIELD FLUX			% MOTOR CURRENT			% PROPELLER TORQUE			% MOTOR HORSEPOWER		
E	Pa	Pb	S	Pa	Pb	S	Pa	Pb	S	Pa	Pb	S	Pa	Pb	S	Pa	Pb	S	Pa	Pb	S	Pa	Pb	S
FREE RUNNING																								
100	146	146	146	100	100	100	100	100	100	100	100	100	68.5	68.5	68.5	100	100	100	68.5	68.5	68.5	100	100	100
80	134.5	134.5	134.5	100	100	100	100	100	100	100	100	100	74.3	74.3	59.5	80	80	100	59.5	59.5	59.5	80	80	80
60	123	123	123	100	100	100	100	100	100	100	100	100	81.4	81.4	48.8	60	60	100	48.8	48.8	48.8	60	60	60
40	107.5	107.5	100	100	100	100	100	100	100	100	100	100	93	93	40	40	40	81.3	37.2	37.2	32.5	40	40	32.5
20	85.5	79	50	85.5	100	100	85.5	79	100	117	100	100	100	100	40	23.4	20	20	23.4	20	8	20	15.8	4
STALLED SHIP																								
100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
80	93	89.5	93	93	100	100	93	89.5	100	107.5	100	100	100	100	86	86	80	100	86	80	86	80	71.6	80
60	84.3	76.5	84.3	84.3	100	100	84.3	76.5	100	118.6	100	100	100	100	71	71	58.5	100	71	58.5	71	60	44.7	60
40	73.7	62	73.7	73.7	100	100	73.7	62	100	135.5	100	100	100	100	54.3	54.3	38.4	100	54.3	38.4	54.3	40	23.8	40
20	58.5	41	50	58.5	100	100	58.5	41	100	171	100	100	100	100	40	34.2	16.8	62.5	34.2	16.8	25	20	6.9	12.5

Fig. 1. Tabulation of calculations necessary to determine the available shaft horsepower under full running and stalled ship conditions with different combinations of engine generator sets in use

E—number of engine generator sets in operation; Pa—parallel-connected generators where engine overload is prevented by decrease in generator field flux; Pb—parallel-connected generators where engine overload is prevented by decrease in engine speed; S—series-connected generators. The tabulation is based on an arrangement of five generators and one motor; a constant horsepower motor speed ratio of 1:46 to 1; and a motor field weakening limit of 40-per-cent flux.

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Handling and Viewing of Radioactive Materials

P. A. HALPINE

The two types of equipment being used to make possible the handling and viewing of radioactive materials without danger to operating personnel while conducting basic physical tests to evaluate these materials are described. Usually the heavier mechanical operations are performed under water, while the shielded cell is used for precision gauging and photography.

FOR the past four years the Westinghouse Electric Corporation, Atomic Power Division, has conducted an extensive program in the development of materials for an atomic power plant. Two laboratories, one at Pittsburgh, Pa., and one at the National Reactor Testing Station in Idaho, have been used in this work. In the early phases of the materials testing, samples of fuel and structural materials were irradiated in nuclear reactors in several parts of the country and then shipped in heavy shielded casks to Pittsburgh. In the more recent testing program, the Idaho Laboratory has been used to examine materials from the submarine prototype power plant reactor, which is now undergoing tests in Idaho. With equipment available in the two laboratories, it is possible with safety to operating personnel to conduct all of the basic physical tests required for evaluation of the suitability and for determination of the performance of power plant materials.

There are two general types of facility which Westinghouse has used for radioactive materials handling. The most simple and also the most economical in first cost is the deep-water pit. When a pit is used, an adequate depth of water will shield the operators from harmful radiation and will also allow observation of the work. In some operations the water can, at the same time, be used to remove heat from the specimen under test. This is important because of the fact that in certain cases the heat release of decaying fission products would be great enough to cause destruction of the sample if the material were cooled by natural air circulation only. Water-pit operation offers many advantages when the type of work permits its use. Simple long-handled tools and an overhead crane serving the area are sufficient for many of the procedures used. When special machines are used the problems of control are simplified since the operating shafts can be brought out above the surface of the water enabling direct access. An example of this kind of installation is an underwater milling machine used in the water pit at Idaho.

The other kind of facility in use at the laboratories is the shielded cell. The cells have thick concrete walls to reduce radiation and protective ventilating systems which prevent contamination from materials inside the cells from being spread to the area outside. The massive concrete walls prevent direct manipulation, necessitating use of remote manipulating devices. The problem of viewing the cell interior has been solved by the use of thick windows which have shielding effectiveness approximately equal to that of the walls. These windows permit direct vision of the test setup. Shielded cells have the advantage over water-pit operation in that many items of conventional testing equipment can be used with little modification. Usually a minor alteration is all that is needed to effect remote control, remote loading, and removal of specimens.

The radioactive materials laboratory at the Reactor Testing Station is located in the power-plant test building. It offers both the deep-pit and dry shielded-cell types of facility, shown in Fig. 1. The deep-water pit is served by the 125-ton crane. This crane also services the submarine hull mock-up. The expanded fuel is removed from the

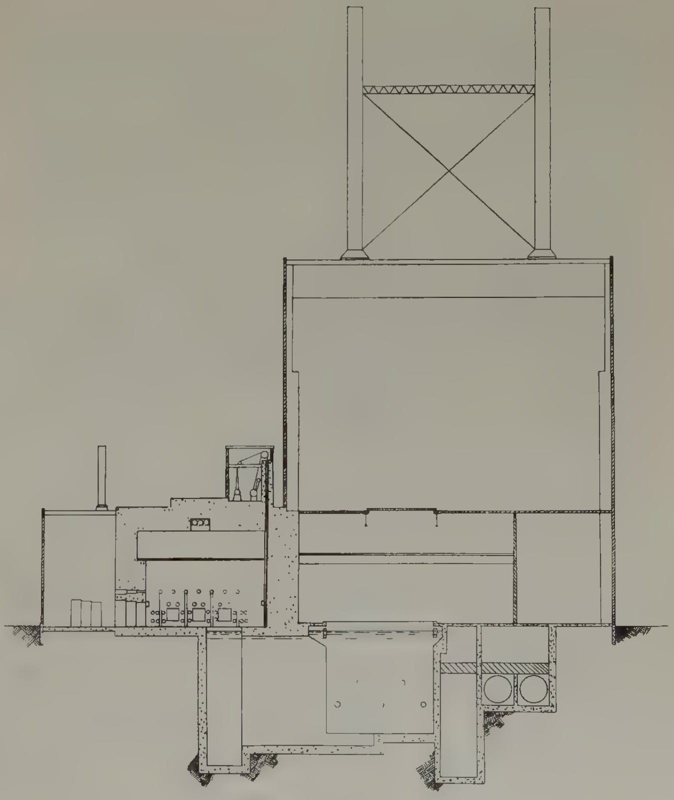

Fig. 1. Section through the main test building

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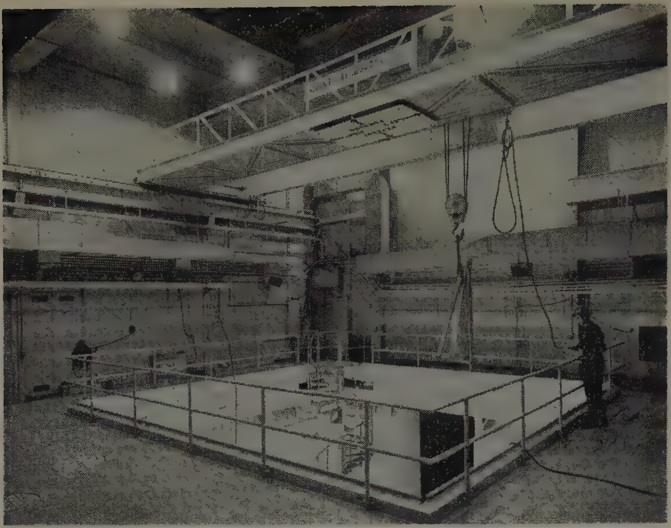


Fig. 2. Deep pit room

reactor vessel and introduced into a heavy lead-shielded container which is then lifted by the crane and lowered through a hatch in the ceiling of the pit room and into the pit. The fuel is discharged into the water for examination and subsequent operations necessary to prepare the material for reprocessing. To insure that no contaminated material is allowed to spread in the pit room, the ventilating system is designed so as to exhaust air through openings in the pit wall above the water surface as shown by Fig. 2. The resulting air flow is down towards the water and across the surface, sweeping away any harmful material. To prevent build-up of contamination particles in the pit water and to maintain its temperature, a pit water circulating pump continuously passes the water through a diatomaceous-earth-type filter and a heat exchanger. Approximately one change of water per day is circulated; a quantity of about 1,000,000 pounds, or 125,000 gallons. The filter also maintains the optical clarity of the water so that good visibility is obtained. This same circulating system is used to maintain the temperature of the pit water by circulating the water through a heat exchanger where it is cooled by water from a spray pond.

Good illumination is necessary for underwater work. The pit walls have been lined with white tile to increase the efficiency of the lighting system. Swimming-pool-type submerged-lighting units are recessed into the walls of the pit. In addition to these lights for general illumination, individual sealed-beam-type spotlights are useful for local high-intensity lighting in particular work areas.

The deep pit provides good general vision of the underwater operation through the surface of the water, but for detailed observation and for work requiring close judgment of position, it is necessary to have special viewers. These are long periscopes which can be lowered into the water. A typical viewer is shown as item 4 in Fig. 3. The watertight box which forms the body of the instrument has plate glass windows in the front. The optical system operates on an electrically operated elevator mechanism behind these windows and makes it possible for the operator to obtain a view from any height through a range of 12 feet. Two of the three instruments used in the pit have duplicate optical systems arranged in parallel to give stereoscopic vision. The objective lens spacing is 6 inches which gives enhanced depth perspective. In addition to the elevator feature the underwater periscopes have a scanning mechanism which operates through a range from 45° above to 45° below horizontal. To scan in azimuth the whole instrument case is rotated about the vertical axis.

To handle materials in the deep pit, both an overhead crane and a special underwater manipulator are installed in the pit room. The standard industrial crane covers the entire room area and is used for general handling of equipment in the pit room. The 125-ton main building crane has been mentioned previously. It has restricted access to the pit room through a small hatch in the ceiling and is used particularly for transferring material to and from the pit room. A general-purpose underwater manipulator operates on tracks mounted at the pit edge as shown by Fig. 4. It is used for handling materials under water. Its lifting capacity ranges from 40 pounds when used at a reach of 3 feet from the column axis, to 100 pounds when the overhang is reduced to 1 foot. In a direct lift on the axis of the column, an 800-pound load can be handled; however, there is very limited maneuverability under this condition.

The grip member of the underwater manipulator is supported by a double-hinged arm member. This gives it a motion resembling the action of a man's arm. The upper and lower joints are synchronized by a chain drive giving a parallel motion when desired. This action is shown in the illustration. The lower hinge joint can also be rotated independently of the upper joint as required. The combination of these two motions gives considerable flexibility in handling objects under restricted space conditions. There are two simple rotating motions in addition to the arm swings. One is about the main column axis and one is about the axis of the grip at the end of the arm. The fifth motion introduced at the grip end of the manipulator is the clamping action. Two interchangeable grips are provided. One is a parallel motion grip which has two flat plate jaws. The other is a hook-type grip which can be used to lift heavier loads or to grip specially shaped shanks on tool equipment. The manipulator is mounted on a double-carriage structure which gives mutually perpendicular motions. The vertical column has a 2-section telescoping arrangement to give 25-foot vertical travel without requiring excessive headroom.

All of the motors driving the eight motions are d-c shunt wound with armature voltage control. The controller which supplies this power is operated by two pistol-grip-type handles. One of the grips controls the three rectilinear motions. The other controls the remaining five motions associated with the grip end. In order to make manual control as simple as possible, the motions of the control handles are related to the manipulator motion. The control handles directly operate snap-action switches in the motor circuits which apply six steps of voltage in each direction of motion. This direct-control system eliminates the necessity for auxiliary control equipment separate from the operator's control box.

The motors actuating the five grip end motions are located under water. To protect these motors and the associated mechanical parts, a pressurized underwater system is used. Dry air is introduced to the enclosed spaces at a pressure above ambient water pressure and O-ring-type seals are used to reduce leakage to a minimum. Any leakage will, of course, be of air into the water and will not be serious if it is not so extensive that the bubbles interfere with vision.

To protect the joints and parts at the grip end from overstress, torque-limiting clutches are used. These permit the motions to slip if an overload occurs.

Stainless steel is used for most of the underwater parts with the exception of the vertical column.

For mechanical operations which require more precise control than is possible with the general-purpose electrically driven manipulator, a direct action "work-station" has been installed in the deep-water pit. An artist's conception of the underwater work-station is shown by Fig. 5. This device has a tool head operated by cables from a control handle at a console at the edge of the pit. Since friction forces in a mechanism of this size are large, a hydraulic-boost mechanism similar to that used in automobile hydraulic power steering units is used. This introduces a proportional force boost which still permits the operator to feel both the amount of motion and the force exerted by the tool head. The work-station is used in conjunction with work-positioning devices which compensate for the restricted travel of the tool head. The tool head can move a distance of 2 feet in each of three mutually perpendicular directions. Ordinarily, the work-station is used with pneumatic tools which can be used to remove or fasten bolts, drill holes, etc.

A typical example of the tools which have been specially developed for underwater use is the underwater milling machine as shown by Fig. 6. This tool is located at the bottom of the pit and has its control console at the edge of the pit above. The horizontal and vertical travel of the work fixture and the cutter feed are driven by long shafts from the console above. These can be operated by hand in the conventional manner. The table is adjusted by handwheels and its position indicated by revolution counters indicating thousandths of an inch. A variable-speed electric drive in the control-console unit actuates the cutter feed screw.

The cutter drive motor, spindle, and speed-reducing belts are enclosed in a watertight housing. As in the case of the underwater manipulator, water is prevented from leaking into the motor space by pressurizing it with dry air. The cutter is driven by a 1.5-hp motor. The cutters are mounted on removable arbors which have a snap lock feature making it easy to replace them with a special long-handled tool.

The machine has been designed for long periods of immersion. The frame is fabricated of stainless-steel plate. The work fixture is cast iron having a high nickel content and is also chrome-plated to secure additional resistance to corrosion. The ways on which cutter head travels, as well as the drive screw for the cutter head, are ground from precipitation-hardened stainless steel to secure good wear resistance. Radioactive cuttings from the milling machine are collected by a hydraulic system which deposits them in an underwater basket for disposal. In addition, a microporous filter is included in the circulation loop to remove finer particles which will pass through the chip basket. To reduce contamination of the pit to a minimum when the milling ma-

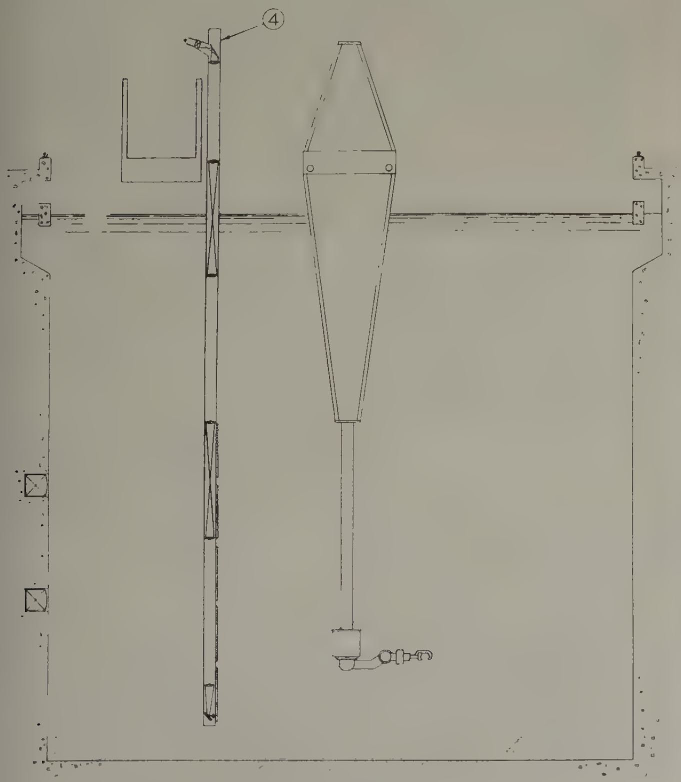


Fig. 3. Section through the deep pit

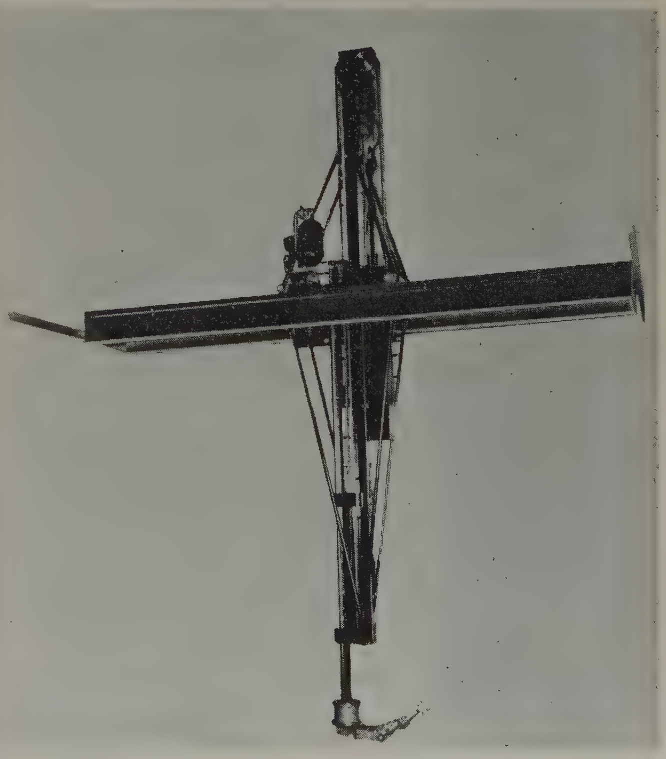


Fig. 4. Underwater manipulator

chine is used, the tool is enclosed in a sheet-steel box which restricts interchange of water. Plastic windows are provided in the hinged top cover so that the operator may observe the operation. Sealed-beam lamps are mounted in the housing for illumination. The chip-collector circulating system returns the water to the closed machine space, making it unnecessary to exchange any considerable quantity of water between the pit and machine housing except when the machine is shut down for loading or unloading.

The work is clamped into the table by hydraulic-cylinder-actuated dogs. This hydraulic system uses pit water so that leakage will not be a problem.

The shielded cell at the Idaho Laboratory is located adjacent to the deep-water pit for convenience in transferring material. Fig. 1 shows the orientation of the cell with respect to the deep pit. An underwater tunnel extends from the pit under the shielded cell. An elevator and a horizontal transfer car are driven by cables from a machinery room located over the shielded cell. When the transfer platten is in its normal position, it forms a section of the floor of the shielded cell. At the other end of its motion, it is brought out to a recess in the pit floor where it is level with the pit floor. The operation of transferring material is done with complete shielding since the platten is not lifted out of the shielding water until it is under the cell.

The ventilating equipment for the shielded cell maintains at all times a slight negative pressure in the cell with respect to the surrounding room. This prevents spread of contamination caused by air leakage. Since the air flow area connecting the cell with the surrounding room varies greatly depending on whether one of the access doors is open or not, an interlock system is arranged to prevent improper operation.

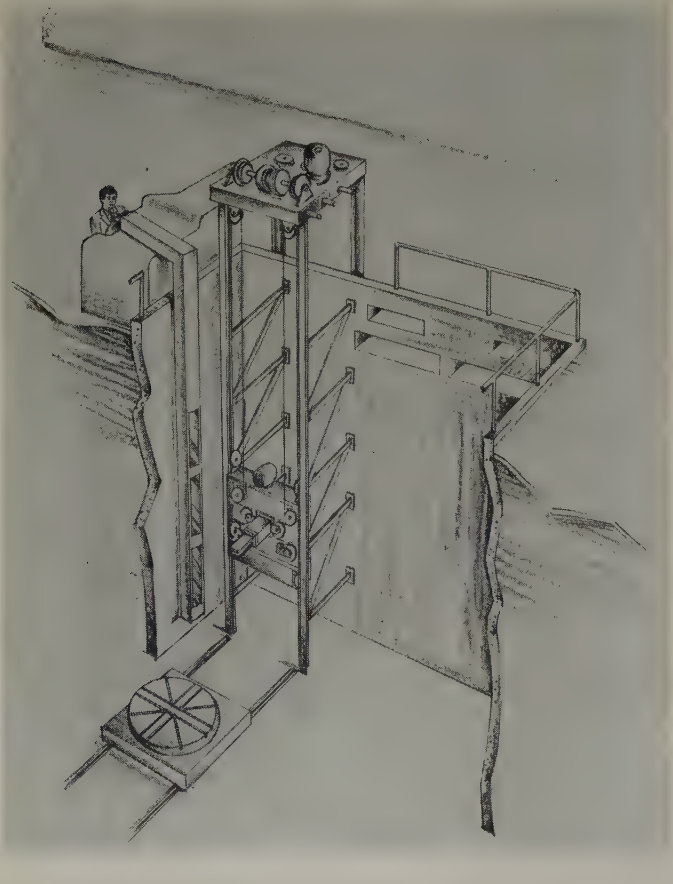


Fig. 5. Artist's conception of deep pit room

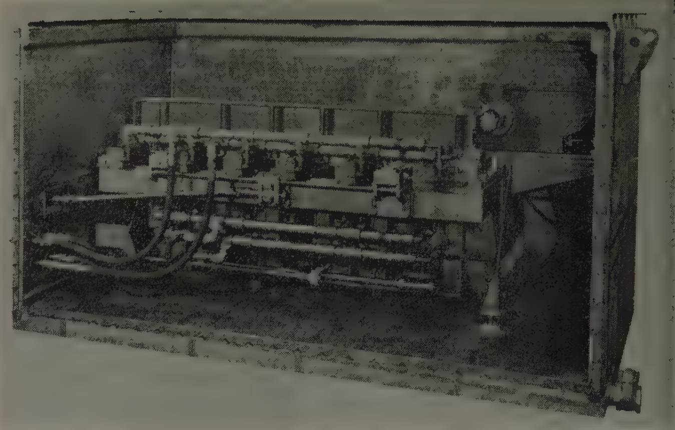


Fig. 6. Underwater milling machine

Additional exhauster capacity is used when the doors are open to eliminate danger of contaminating the area. The air exhausted from the cell is filtered before being discharged through stacks to the outside atmosphere.

The walls of the cell are of 7-foot thick concrete. The inside floor area is 15 feet wide, 25 feet long, and 25 feet high. To provide for flexibility in installing and operating experimental equipment, a large number of removable plugs have been installed in the walls. One of these plugs, rolling on rails located at the end of the cell, is 5 feet wide and 6 feet high. It is used as the normal access door for personnel and equipment. There are three smaller plugs on each side of the cell which also roll on rails. These are 3 feet square and are used with specific equipment setups. In such a case, the apparatus can be mounted on the inside face of the plug and can then be removed from the cell by withdrawal of the plug. A large number of smaller holes are provided both in the large plugs and in the walls around the plugs. These holes are filled with dummy shielding plugs when not in use, but can be fitted with mechanical control shafts, electrical cable entry plugs, or with air or hydraulic lines. In each case the design must be such that no straight through leakage path results, and that over-all shielding effectiveness of the wall is preserved.

For observations of operations inside the shielded cell, both direct-vision windows and periscopic optical systems have been used. Any one of the seven large shield plugs can be removed and replaced with a special plug with a built-in window. At present only one such window is available. It has been built for use in the 3-foot openings.

Two kinds of periscopic viewers are in use. The first is a wide-angle type, one of which is installed at each of the four corners of the cell. These units cover a field of view about 90° in angle, that is, from wall to wall when looking out from a corner. The image seen by the observer is reduced in size as compared with the size that objects would appear to be if seen from a point inside the shield wall. The appearance of the image might be compared to a post card sized picture of the interior. The other kind, called an elevator periscope, is used in the shielded cell to give a more detailed view at unity power of a smaller area of the cell. This is convenient for observing a particular operation as seen from a point inside the cell. The elevator periscopes have three scanning motions, each provided by an electric motor drive on the objective lens assembly inside the cell. One raises and lowers the head through a 6-foot range in height. Another rotates the scanning mirror to give a viewing angle through a range from 45° above horizontal to 45° below. The third motion is a rotation of 180° in azimuth, that is, about the vertical axis.

The remote handling of materials in the cell is done by two general-purpose electric manipulators, similar in construction to the underwater manipulator described previously, which are shown in the c over picture. These units actually served as the prototype for the development of the underwater manipulator and have the same motions. They differ chiefly in that they have a shorter rail span and vertical range of column motion. In order to increase the range of vertical travel without using a long manipulator column motion, three track levels have been installed in the cell. These tracks are at 3-foot intervals. This adds 6-foot travel to the 7-foot travel provided by the manipulator. There is another advantage to a multiple-track installation: it makes the two manipulators more nearly independent of each other, since one may pass over or under the other when on a different track. To secure this independence of operation, each manipulator is associated with its own elevator at one end of the cell. Interlocking switches insure that the elevator cannot be operated unless the manipulator is in proper position. The cable which powers the manipulator is fed as required by a dead-weight loaded-pulley arrangement. This scheme eliminates the need for sliding trolley contacts or for brushes and slip rings which would be used on a cable drum-storage unit. The transverse carriage and column motion on the manipulator is also accommodated without sliding contacts through the use of coiled flexible cables.

With two kinds of material-handling facilities available, it is possible to use the more effective for any particular operation. In general, it has proved more practical to do the heavier mechanical operations under water. Precision gauging, photography, and other similar work is generally done in the shielded cell.

Hydraulic Turbine-Driven Generators Installed at McNary Dam

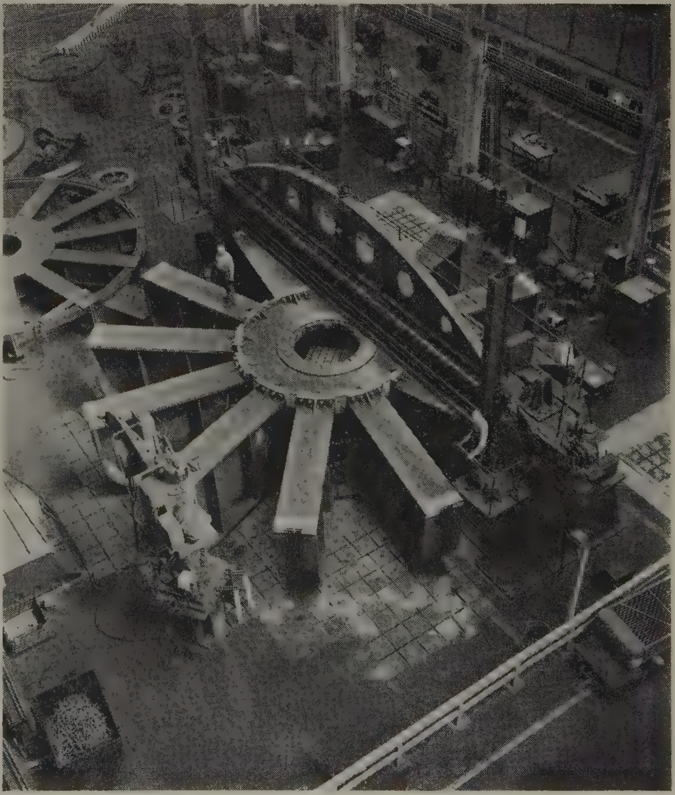
The hydrogenerators at McNary Dam on the Columbia River are the largest pieces of rotating electrical equipment in physical size ever manufactured. Each of these powerful giants is 52 feet in diameter, weighs 1,200 tons, and requires approximately 40 freight cars to transport it.

The 12 powermakers are being manufactured by the large motor and generator department of the General Electric Company, Schenectady, N. Y. At present, 4 generators are in operation at McNary Dam, with the last of the 12 scheduled for shipment in 1955.

The 70,000-kw hydrogenerators are designed by General Electric to specifications prepared by the U. S. Army Corps of Engineers. They are designed to meet a number of unusual requirements including the characteristics of the Columbia River at the powerhouse site. The 12 units will require 6,000,000 man-hours of labor or the equivalent of 3,000 men working for a full year.

A spectacular generator design feature is the thrust bearing which must carry a load of over 4,000,000 pounds. This is by far the largest load that has ever been carried on any thrust bearing and represents a 33 per cent increase over the high bearing loads at Bonneville Dam, previously the heaviest in the world. The thrust bearing on vertical generators must support the weight of all rotating parts of the turbine, the generator rotor and shaft, and the thrust of the water flowing through the turbine.

Each of the McNary generators will revolve at a speed of 85.7 rpm, a comparatively slow speed made necessary by the large quantities of water available to turn the hydraulic turbines, and the low "head," or distance the water drops in turning the turbines.



Forty-one-foot bearing bracket for one of the hydraulic turbine-driven generators at McNary Dam on the Columbia River is shown on a boring mill at the General Electric Company, Schenectady, N. Y. The generators, 52 feet in diameter, are the largest pieces of rotating electrical equipment in physical size ever manufactured and weigh 1,200 tons each

Sampled-Data Processing for Feedback Control

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FEEDBACK CONTROL SYSTEMS in which the data at one or more points are in the form of pulse trains or sequences of numbers are known as sampled-data feedback control systems. These systems are most readily analyzed[1,2] in terms of the so-called z-transforms which are the Laplace transforms of impulse-modulated time functions with the delay operator ϵ^{-nTs} replaced by the variable z^{-n}.

Stabilizing and shaping these systems involve more troublesome problems than encountered with comparable continuous systems. Conventional stabilizing methods, such as the insertion of linear networks in the continuous portions of the systems, have serious limitations.

A more effective method is to process the samples themselves. The unit which accomplishes this is called the sampled-data processing unit and may be implemented by a digital or analogue computer. The unit operates by storing and weighting a finite number of its own past and present input and output samples, combining them linearly to produce an output pulse beneficial to system response at each sampling instant.

The z-transform of the processing unit pulse transfer function is

$$\frac{E_2^*(z)}{E_1^*(z)}=D^*(z)=\frac{a_0+a_1z^{-1}+a_2z^{-2}+\ldots+a_jz^{-j}}{b_0+b_1z^{-1}+b_2z^{-2}+\ldots+b_kz^{-k}} \tag{1}$$

The coefficients can be chosen arbitrarily by choice of the digital or analogue computer program. The one requirement of physical realizability is that b_0 always be present in equation 1, in order to have a real time output without requiring future values of input.

Previous work has been directed toward using this pulse transfer function to shape the frequency locus of the open-loop transmission,[3] or to the adjustment of the roots of the characteristic equation of the closed-loop transmission.[2] By contrast the technique outlined here is used to synthesize systems whose response in the time domain to a test input is prescribed. This is facilitated by the ready time domain interpretation of the over-all transmission when expressed as a polynomial in z^{-1}. When expressed in this way the effect of $K^*(z)$, Fig. 1, is to delay and weight the input sample sequence. For example, if $K^*(z)$ is chosen to be z^{-1}, the sampled output equals the sampled input delayed by one sampling period.

Within certain limitations a choice of $K^*(z)$ can be made and the associated $D^*(z)$, Fig. 1, determined from the system equations.[1] For many systems prototype responses to specific input time functions can be achieved. These prototype responses represent the theoretically fastest possible complete closures of sampled error. For example, the prototype response to a step input provides for complete closure of sampled error in one sampling interval, while for a ramp input two sampling intervals are required.

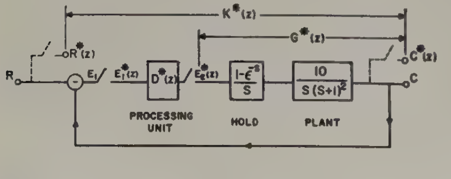

Fig. 1. System stabilized with sampled-data processing unit

The limitations on the choice of $K^*(z)$ relate to the necessity for limiting the output of the processing unit to values which do not saturate the continuous plant which follows, and to considerations of stability which prohibit the cancellation by the processing unit of zeros of the pulsed plant transfer function $G^*(z)$ lying outside of the unit circle. Within these limitations the response can still be optimized for the fastest possible closure of sampled error.

As an illustration, the system of Fig. 1, which when uncompensated is highly unstable even in the continuous case, can be stabilized with the processing unit for a closure of sampled error in three sampling periods using a ramp as an input test function. The processing unit for this case has a transfer function given by

$$D^*(z)=\frac{0.81-0.81z^{-1}+0.19z^{-2}}{1.00+0.35z^{-1}-1.16z^{-2}-0.19z^{-3}}$$

Transformed into the time domain this requires that

$$E_2(nT)=0.81\,E_1(nT)-0.81\,E_1(n-1)T+0.19\,E_1(n-2)T-0.35\,E_2(n-1)T+1.16\,E_2(n-2)T+0.19\,E_2(n-3)T$$

The modest requirements on the processing unit include the storage and weighting of two past input samples and three past output samples. Notice that while the prototype response for a ramp input closes out sampled errors in two periods, in this example the location of a zero of $G^*(z)$ outside the unit circle makes a minimum of three sampling periods necessary.

Where they are economically justified, sampled-data processing units appear desirable for shaping sampled systems to time domain specifications. While applicable only to sampled-data systems, this does not preclude the introduction of sampling into otherwise continuous systems. In many cases, particularly where process lags are a problem, the application of these techniques seems indicated.

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Testing Point-Contact Transistors for Pulse Applications

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Test methods are recommended and described. Conclusions are drawn regarding measurements for determination of proper application of transistors to large-signal pulse circuits.

WHEN point-contact transistors are used in pulse or switching circuits, their nonlinear, large-signal characteristics rather than their linear small-signal characteristics, are of primary importance. This article recommends and describes methods of test for large-signal pulse applications.

In small-signal applications, such as linear amplifiers, the point-contact transistor can be represented by a 2-terminal pair network whose input is described by voltage, v_1, and current, i_1, and whose output is described by voltage, v_2, and current, i_2. There are six ways[1] of specifying this network in terms of v_1, i_1, v_2, and i_2. The combination that specifies open-circuit impedances is most convenient, since most point-contact transistors designed for switching applications are potentially unstable when short-circuit admittance measurements are attempted. Four open-circuit impedance parameters can be measured,[2] as suggested by equations 1 and 2, that describe the point-contact transistor in small-signal applications

$$v_1 = z_{11}i_1 + z_{12}i_2 \quad (1)$$

$$v_2 = z_{21}i_1 + z_{22}i_2 \quad (2)$$

Caution must be exercised in using these four impedance parameters because of their operating-point and frequency dependence. Measurements are usually made at low audio frequencies where the impedances reduce to resistances and the operating point is selected in terms of the emitter current and collector voltage.

In pulse applications, the point-contact transistor cannot be entirely specified in terms of the small-signal parameters since the operating point undergoes a large excursion, oftentimes from a low-current cutoff region (OFF condition) to a high-current, saturation region (ON condition). Thus, it is necessary to consider large ranges of the dynamic and static characteristics.

Typical input and output static characteristics of point-contact transistors are shown in Fig. 1. These characteristics can be divided into three regions as follows:

Region I. A region in which both the emitter and collector currents are in the reverse direction. Considered as a switch, the transistor is in the OFF condition. This region can alternatively be called "collector current cutoff" or "collector voltage saturation."

Region II. A region in which the emitter current is in the forward direction, and the collector current is not limited primarily by the external collector circuit. This region is usually called the "active region" and with reasonable accuracy can be specified in terms of a set of 2-terminal pair parameters.

Region III. A region in which the emitter current is in the forward direction, and the collector current is limited primarily by the external collector circuit. Considered as a switch, the transistor is on the ON condition. This region can alternatively be called "collector current saturation" or "collector voltage cutoff."

The analysis of circuits in which the transistor operating point may traverse two or more of the above regions involves a high degree of nonlinearity. To a first approximation, however, the switching or pulse behavior can be determined using the idealized characteristics shown in Fig. 1, in which linearity is assumed within each region. Thus, the philosophy behind large-signal measurements becomes apparent. A set of d-c, dynamic, and static parameters are chosen that describe the pertinent behavior of the point-contact transistor in each of the three regions.

MEASUREMENT CLASSIFICATION

MEASUREMENT of the following d-c, static, and dynamic parameters will provide the information required for most pulse applications. This listing may be expanded or abbreviated to conform with the requirements of any specific application.

D-C Measurements:

1. $r_E(V_E,\ I_C)$, the reverse resistance of the cutoff emitter with $I_C=0$.

2*A*. $r_C(I_E,\ V_C)$, the reverse resistance of the cutoff collector with $I_E=0$.

The first of a series of three special articles on point-contact transistors which will appear in *Electrical Engineering*.

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The transistor application studies sponsored by the General Electric Company Heavy Military Electronics Equipment Department, Syracuse, and by the General Electric Company Advanced Electronics Center, Ithaca, provided the background for this article. In addition, some of this material has been submitted to Institute of Radio Engineers-AIEE Transistor Measurement Task Force 7.7.4 for use in the forthcoming standards of measurement, thus credit is due Bell Telephone Laboratories, Inc., Radio Corporation of America, International Business Machines Corporation, and Sylvania Electric Products Inc, for suggestions and editing.

The symbolic terminology utilized in this article follows the proposed system presently being considered by the joint AIEE-IRE Semi-Conductor Task Force Committees. The principal letter of the symbol designates the electrical function to be described. In the case of resistance, a capital R signifies an external resistance of the circuit, while a lower case r signifies the internal resistance of the transistor. For voltages and currents, a capital letter signifies a d-c or a-c (rms) value, while a lower-case letter signifies an instantaneous value.

Subscripts are used to indicate the individual element involved. For voltages and currents, capital-letter subscripts indicate direct current, and lower case subscripts indicate alternating current. Where ambiguity exists, a second subscript designates the datum or reference point.

2*B*. $I_C(I_E, V_C)$, the collector current with $I_E=0$.

Note: $I_C(O, V_C)=\dfrac{r_C(O, V_C)}{V_C}$

3. $r_B(I_E, V_C)$, the base resistance with $I_E=0$.
4. $I_C(I_E, V_C)$, a measure of the average alpha, (α_{av}) for a specified incremental change in I_E at a constant V_C.

Note: $\alpha_{av}=\dfrac{I_C(I_E, V_C)-I_C(O, V_C)}{I_E}$

5. $V_C(I_E, I_C)$, the saturation collector voltage at a specified I_E and I_C.

Static Measurements:

6. V_E versus I_E curves with I_C as a parameter (r_{11} characteristic).
7. V_C versus I_C curves with I_E as a parameter (r_{22} characteristic).

Dynamic Measurements:

8. α_{ce} versus I_E curves with V_C as a parameter.
9. Frequency response.
   - A. α_{ce} versus frequency.
   - B. Pulse response.
     Turn-on time (rise time).
     Turn-off time (storage time or delay time and fall time).
     Ohmic delay time.

D-C MEASUREMENTS IN REGION I

In Region I both the input terminal pair and the output terminal pair are biased in the reverse direction. Consequently, relatively small currents are flowing in the emitter and collector circuits, and the transistor functions as a passive network. Since the collector current is essentially cut off (collector voltage saturation), the device is analogous to a switch in the OFF condition. In this condition the slope of the input static characteristic curve $(r_{11}=r_e+r_b)$ is large compared to the slopes encountered in Regions II and III, and is essentially equivalent to the reverse resistance of a simple diode. Similarly, the slope of the output static characteristic curve $(r_{22}=r_c+r_b)$ is essentially equivalent to the reverse resistance of a diode.[3]

Measurement of Reverse Emitter and Collector Resistances. In pulse applications it is common practice to specify the ratios of direct voltage to direct current at some specified operating point, rather than completely inspect r_{11} and r_{22} in Region I. Thus, the following measurements can be made with the simple circuit arrangement of Fig. 2.

$$r_E(V_E, I_C)=\frac{E}{I_E} \tag{3}$$

where $I_C=0$, and V_E specified (−10 volts).

$$r_C(I_E, V_C)=\frac{V_C}{I_C} \tag{4}$$

where $I_E=0$, and V_C specified (−15 volts).

The relatively small effect of the Region I base resistance, r_B, is included in r_E and r_C in the above measurements. The measurements of r_E and r_C may be compared with established standards to determine acceptability for a given application, see Table I.

The reverse resistances, r_{11} and r_{22}, also can be measured by oscillographic methods. These methods of test have the advantage of exhibiting any irregularities or breaks in the curves occurring in any specified operating range.

Measurement of Reverse Collector Current. An alternative method of characterizing the collector is to measure the reverse collector current at a specified collector voltage (−15 volts). In this test the emitter is open-circuited, i.e., $I_E=0$. This current, $I_C(O, V_C)$, is of particular interest in large signal measurements. For example the product $I_C(O, V_C)\times(R_B+r_B)$ locates approximately the peak point in negative resistance circuits. This peak point marks the boundary between Regions I and II and influences the selection of trigger and bias magnitudes.

Measurement of Base Resistance. The base resistance, r_{12}, measured by small-signal methods in the active region cannot be used to determine accurately the peak point. For this purpose the base resistance, $r_B(I_E, V_C)$, may be

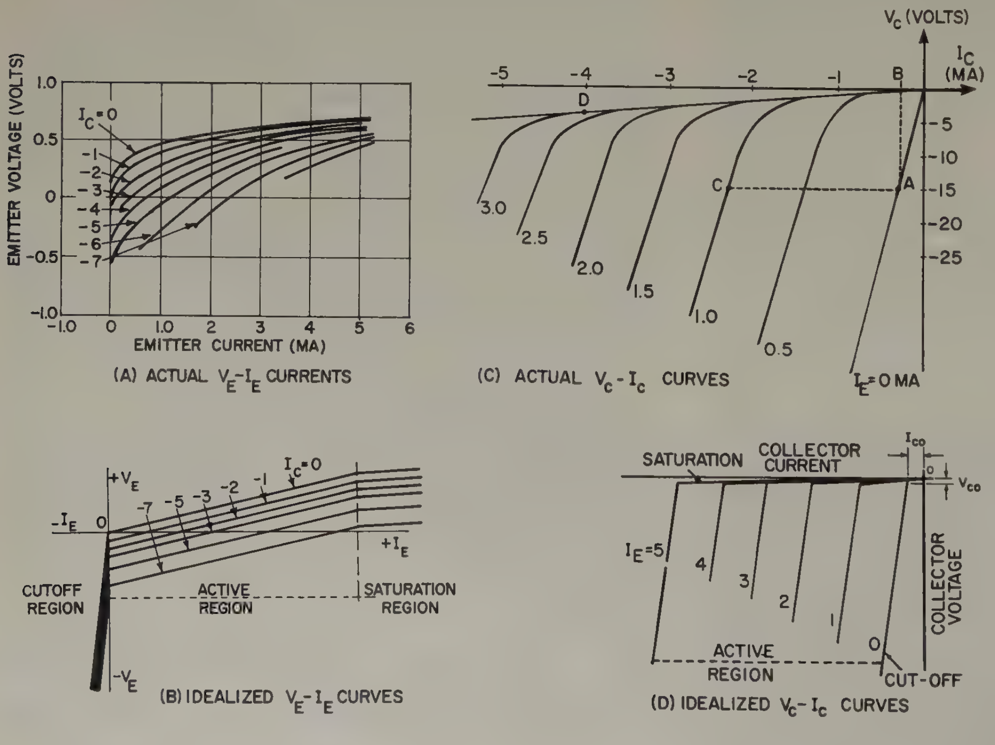


Fig. 1. **Point-contact transistor static characteristics**

Table I. Typical Measurement Results and Specifications

Parameter	One Manufacturer's Specifications	Measured Conditions	One Circuit Designer's Requirements	Typical Averaged Measurements		
				A	B	C
α_{av}	2.5 min.	$\Delta I_C=0$–1ma $V_C=-15$v	2.5 min.	2.54	2.85	2.35
r_C	20K min.	$I_E=0$ $V_C=-15$v	150K min.	33K	24K	27K
I_C	0.75ma max.	$I_E=0$ $V_C=-15$v	0.10ma max.	0.57ma	0.60ma	0.63ma
r_E	100K min.	$I_C=0$ $V_E=-10$	100K min.	Not measured		
r_B	500 ohm	$I_E=0$ $V_C=-15$v	50 ohm	272 ohm	39	114
V_{C34}	2.0 max.	$I_E=+3$ma $I_C=-4$ma	1.0 max.	1.74v	1.22v	1.35v
Rise time	0.2 μsec.	10–90% amplitude	0.1 μsec.	0.08	0.65	0.11
Fall time	0.2 μsec.	90–10% amplitude	0.1 μsec.	0.08	0.30	0.09
Ohmic delay	% >0.02 sec.		Negligible	25%	75%	0
	Max. value		Negligible	0.1 μsec.	0.1 μsec.	Neg.

measured at $I_E=0$, in the transition region between Regions I and II. This value of $r_B(I_E, V_C)$ plus any external resistance, R_B, may be used in conjunction with the reverse collector current, $I_C(O, V_C)$, to determine the peak point.

The base resistance, $r_B(O, V_C)$, may be determined at a specified value of V_C (−15 volts) by open-circuiting the emitter and measuring the emitter to base voltage, V_E, with a sensitive d-c vacuum tube voltmeter. The base resistance may then be calculated by utilizing the ratio

$$r_B(O, V_C)=\frac{V_E}{I_C} \tag{5}$$

Precautions. In making d-c measurements of the reverse resistance, the collector current, and base resistance in Region I, the following factors must be considered.

1. Care must be taken not to exceed maximum allowable current, voltage, and power ratings. Cumulative heating effects can cause a gradual shift in the measured values.
2. Under collector reverse bias conditions, leakage currents between emitter and collector may be observed by an increase in emitter to base potential. This leakage current may affect adversely the operation of some circuits.
3. Instability may result if suitable resistance is not provided in series with the bias sources, particularly in the case of point-contact transistors that are, in general, short circuit unstable.
4. The measured parameters vary with age, temperature, and humidity.

MEASUREMENT OF D-C GAIN IN REGION II

REGION II is the active region where emitter current flows in the forward direction, and the collector current is less than its saturation value. The static and dynamic measurements previously suggested are more completely descriptive of the device in this region. Nevertheless, the d-c gain or average alpha, α_{av}, is a convenient measure of the current sensitivity of the device and is defined by the equation

$$\alpha_{av}=\frac{I_C(I_E, V_C)-I_C(O, V_C)}{I_E} \tag{6}$$

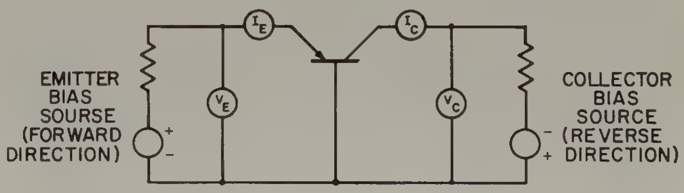
where V_C and I_E are specified values ($V_C=-15$ volts; $I_E=1$ ma). This parameter is frequently used as a forming objective in the fabrication of point-contact transistors.

D-C MEASUREMENTS IN REGION III

IN Region III the emitter is biased in the forward direction and the collector current is limited primarily by the external collector circuit. Consequently, relatively large currents flow in the emitter and collector circuits which result in the transistor acting as a passive network. Under these saturation conditions the slope of the input static characteristic curve (Fig. 1*A*, 1*B*) is essentially the forward resistance of the emitter as a simple diode in series with the saturation base resistance ($r_{11}=r_e+r_b$). Similarly, the slope of the output static characteristic curve, for low values of collector voltage (Fig. 1*C*, 1*D*), is essentially the forward resistance of the collector as a simple diode in series with the saturation base resistance ($r_{22}=r_c+r_b$).

Measurement of Saturation Collector Voltage. The $V_C(I_E, I_C)$ parameter, in Region III, is the voltage from collector to base when the emitter and collector current values are chosen so that the point of measurement is near the r_{22} knee but definitely in Region III ($I_E=+3$ ma and $I_C=-4$ ma). Under these measurement conditions, the measured value of $V_C(I_E, I_C)$ gives an indication of the nearness of the saturation curve to the $V_C=0$ axis, and hence a measure of the transistor's effectiveness as a switch. The saturation curve is the curve between the $V_C=0$ axis and the r_{22} knee where all curves tend to coincide. The value of collector voltage under these current conditions may be measured by adjusting the emitter and collector currents to the desired values and then measuring the collector to base voltage.

Precautions. Parameter measurements in Region III are subject to variations due to excessive collector currents. Under these conditions the collector current may increase



I_E
I_C
EMITTER BIAS SOURSE (FORWARD DIRECTION)
V_E
+
-
V_C
-
+
COLLECTOR BIAS SOURCE (REVERSE DIRECTION)

Fig. 2. Circuit diagram for d-c measurements: I_E=emitter current; V_E=emitter voltage; I_C=collector current; V=collector voltage

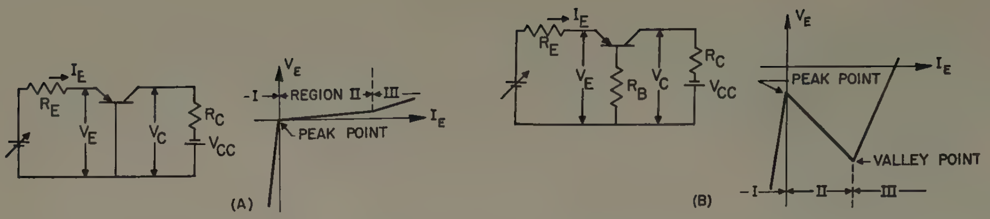
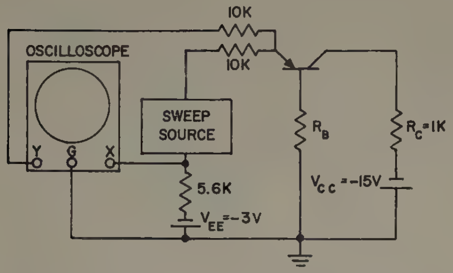


Fig. 3. **V_e versus I_E static characteristics: A—Transistor without external base resistance; B—Transistor with external base resistance (R_B added)**



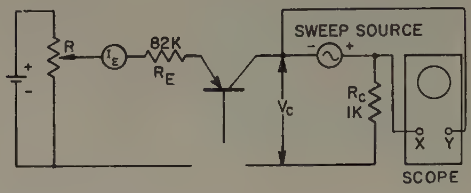


Fig. 4 (left). ***N*-curve tracer.** **Fig. 5 (right).** **Circuit for displaying the V_C versus I_C curves**

slowly or quite rapidly to large values which may cause an over-all deterioration of the transistor characteristics and usually results in complete destruction of the transistor.

When d-c measurements are to be made in Region III, it is necessary for the emitter current to be adjusted first. If the collector current is adjusted first, excessive collector voltage will result unless protective measures are taken. Excessive collector voltage will cause permanent damage to the transistor.

STATIC MEASUREMENTS

THE most convenient design tool in pulse and other large-signal applications is a set of static characteristics that graphically indicate the paths and regions of operation. Four sets of static characteristics are needed to describe the transistor completely:

V_E versus I_E curves with I_C as a parameter (r_{11} family)
V_E versus I_C curves with I_E as a parameter (r_{12} family)
V_C versus I_E curves with I_C as a parameter (r_{21} family)
V_C versus I_C curves with I_E as a parameter (r_{22} family)

In most pulse applications, the r_{11} input resistance and the r_{22} output resistance are sufficiently informative, so only these two static families are recommended as standard measurements. Also, in most pulse applications short rise and fall times are desirable. This fast action can be best realized with regenerative circuit arrangements that make use of a negative resistance at the input terminals of the transistor; consequently, the V_E versus I_E static characteristic which is of primary importance is the negative resistance curve.

V_E versus I_E With I_C as a Parameter. The input resistance of a point-contact transistor is potentially negative, and as a result, it is capable of regenerative or oscillatory operation, provided the proper external impedances are connected. In the grounded-base emitter-input configuration, for example, the input resistance is given by[4]

$$r_{11}=r_E+r_B(1-\alpha_{ce}) \qquad (7)$$

assuming $r_C>>R_C$, $r_C>>r_B$, and $r_M=\alpha r_C$.

Thus, with point-contact transistors where $\alpha_{ce}>1$, r_{11} can be negative depending on the relative magnitude of the two terms. To insure that r_{11} is negative, an external resistance, R_B, can be added in series with r_B. Fig. 3 illustrates a typical input resistance or static V_E versus I_E curve for a point-contact transistor. In Fig. 3*A*, the curve is slightly positive in the active region (Region II). In Fig. 3*B*, the addition of the external resistance, R_B, results in a negative resistance in the active region. It is important to note that many transistors exhibit the negative resistance or *N* curve characteristic without the addition of an external resistance, R_B.

The negative resistance characteristic that has been discussed is not uniquely descriptive of the emitter circuit. In pulse and switching applications, the collector or base also can be employed as an input circuit, and a negative resistance can be realized, see reference 4. The emitter-input configuration is selected for making standard measurements only on the basis of its more common occurrence.

The negative resistance or *N* curve version of the V_E versus I_E static curve often serves as a figure of merit in circuit investigations. However, it provides little information that is not obtained from the d-c measurements previously described for Regions I, II, and III. This fact is evident upon inspection of a typical static characteristic as shown in Fig. 2.

In Region I, the slope of the curve can be approximated by $r_{ER}+r_B+R_B$ which is the reverse resistance of the emitter diode in series with the internal (r_B) and external (R_B) base resistance. In practice

$$r_{ER}>>r_B+R_B \qquad (8)$$

so the slope is essentially equal to r_E, and is in general so large that it is practically a vertical line on the oscilloscope for any convenient scale. Thus, the *N* curve does not yield a very useful value of r_{ER}.

In Region II, the slope is approximately

$$R_B(1-\alpha_{ce}) \qquad (9)$$

assuming $R_B>>r_B$, $r_C>>R_B$, and $R_B>>r_E$.

Resistor R_B is a known value that is added externally to the circuit. Consequently, this slope yields only an awkward measurement of α_{ce} that is no more useful than α_{av} obtained by simple direct-current measurements or from the collector family.

In Region III the slope of the N curve is given by the emitter forward resistance (r_{EF}) and the base resistance. However in practice

$$R_B >> r_{EF} + r_B \tag{10}$$

so R_B, a known external resistor, governs the slope and masks the effect of r_{EF}.

In some applications, the location of the peak point, V_{EP}, is of interest. It can be obtained directly from the V_E versus I_E curve. This voltage is also given by

$$V_{EP} = I_C(O, V_C) \times (R_B + r_B) \tag{11}$$

where I_C and r_B are obtained by previously described d-c measurements and R_B is a known external resistor. Furthermore, in most applications the peak points are stabilized by using diodes and voltage sources to clamp these points to definite fixed voltages.[5] Thus, a direct measurement of V_{EP} is of little value.

From the foregoing, one can conclude that V_E versus I_E negative resistance curves tell little about a transistor that cannot be learned more easily by simple d-c measurement. Consequently, the N curve should not be considered as a standard measurement. Nevertheless, this type of curve is often desired to determine whether or not a transistor possesses an inherent negative resistance, and to compare various transistors in specific circuit configurations where a negative resistance is required.

Fig. 3 shows a circuit for obtaining a negative resistance curve (N) by point-by-point methods. Resistor, R_E, should be large so that the battery appears like a constant current source. If R_B is needed to produce the N curve, a standard value, $1K$, for example, should be selected so that the N curves measured have a common basis of comparison. Fig. 4 indicates a method of measuring a dynamic N curve. A voltage proportional to I_E is applied to the X-axis of the oscilloscope; the voltage, V_E, is applied to the Y-axis. A simple sweep source can be obtained by applying a 115-volt 60-cps power-line signal to a cascaded variac, isolation transformer, half-wave rectifier, and resistor load ($5K$). The sweep voltage generated across the resistor load "floats" with respect to ground, and is introduced into the test circuit as shown in Fig. 4.

V_C Versus I_C With I_E as a Parameter. Fig. 1C illustrates a typical output static characteristic that plots collector voltage versus collector current with emitter current as a variable. This family of curves is analogous to the plate characteristics of a vacuum tube. It can be used similarly to study the path of operation along a load line and to approximate distortion, dissipation, saturation regions, cutoff regions, etc.

The circuit for obtaining an oscillographic presentation of these curves is shown in Fig. 5. Resistor, R_E ($82K$), is included to insure stability; R_C ($1K$) limits the collector dissipation and provides a measure of I_C. Potentiometer, R, is used to set I_E for each V_C versus I_C curve.

This static collector characteristic also provides reasonably accurate values of the d-c parameters previously described. For example:

1. r_C, the reverse resistance of the cutoff collector is obtained at point A.
2. I_C, the collector current with $I_E = 0$ is obtained at point B.
3. α_{av}, the average alpha is given by the collector current increment between points A and C.
4. V_{C_M}, the saturation collector voltage, is obtained at point D.

Precautions. Sometimes the static curves will exhibit certain irregularities. This erratic behavior is often the result of inherent faults in the transistor that cannot be eliminated by the user. On the other hand, inadequate precautions in the arrangement of the test circuits might generate these irregularities.

Sufficient resistance must be used in series with the bias sources; lead and circuit capacitances must be minimized to insure stability; and suitable grounds must be established. In other words, high-frequency circuit techniques must be carefully applied in the design, construction, and use of the test equipment.

DYNAMIC MEASUREMENTS

The current gain, α_{ce}, may vary widely with operating point, i.e., its value is a function of collector voltage and emitter current. Also, α_{ce} varies with frequency. Consequently, it is important to be able to measure this operating point and frequency dependency if optimum designs in terms of pulse gain, rise time, fall time, and switching time are to be realized.

α_{ce} Versus I_E Measurements. A typical α_{ce} versus I_E characteristic is shown in Fig. 6. This curve can be obtained by d-c, a-c, or sweep methods:

1. *D-C Methods of Obtaining α_{ce} Versus I_E.* Fig. 3

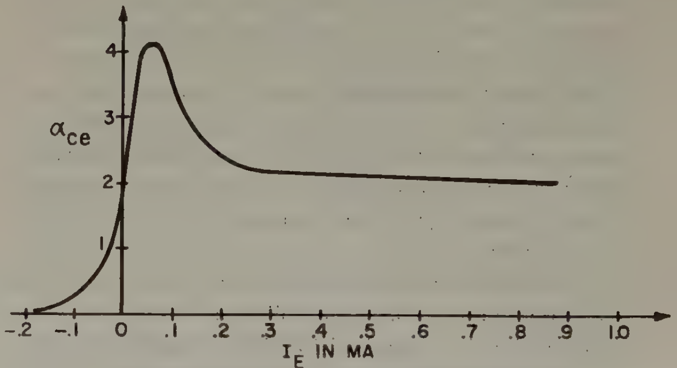


Fig. 6. α_{ce}, versus I_E characteristic

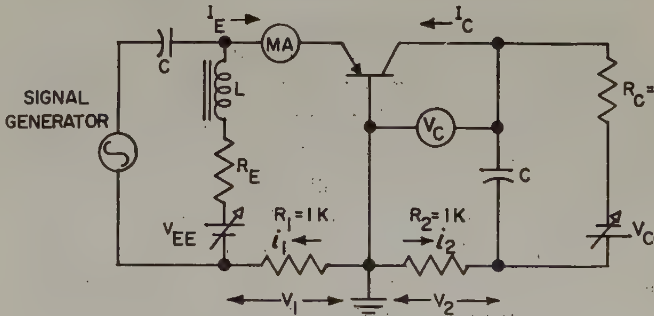


Fig. 7. A-c method of measuring α_{ce} versus I_E

indicates a method of obtaining d-c measurements of α_{ce}. Resistance, R_E, is selected large ($100K$) compared to the input resistance in order that the I_E source approximates a constant current source. Resistance, R_C, is selected small ($1K$) compared to the output resistance in order that the measured alpha is practically equal to the short circuit current gain. R_C is needed as a precautionary limiting resistor. By definition

$$\alpha_{ce}=\frac{\Delta I_C}{\Delta I_E} \tag{12}$$

with constant V_C (−15 volts). Data for graphically plotting a complete dynamic curve can be obtained by measuring successive current increments throughout the operating range of interest.

2. *A-C Methods of Obtaining α_{ce} Versus I_E.* Fig. 7 indicates a method of obtaining a-c measurements of α_{ce} at low frequencies (270 cps). Inductor, L, offers a high impedance to the signal frequency and serves to isolate the bias source. Capacitor, C, is essentially a short circuit at the signal frequency. Here again ($R_E + R_1$) is large compared to the input impedance of the device and R_2 is small compared to the output impedance. The magnitude of alpha is given by the ratio i_2/i_1, with V_C a constant. It is convenient to measure V_2 and V_1 with a vacuum-tube voltmeter across precision resistors, R_1 and R_2. Then

$$\alpha_{ce}=-i_2/i_1=-\frac{V_2/R_2}{V_1/R_1}=\frac{V_2}{V_1} \tag{13}$$

3. *A Sweep Method of Obtaining α_{ce} Versus I_E.* Fig. 8 indicates a method[6] of sweeping the I_E bias and obtaining a measure of α_{ce} so that an α_{ce} versus I_E plot is available for oscillographic presentation. Best results will be obtained if the sweep current generator frequency is low (33 cps), and the signal generator frequency is a medium value (100 kc). The inductance-capacitance antiresonant circuit isolates the sweep source from the signal source. The capacitor has a large reactance at the sweep frequency and a low reactance at the signal frequency. The resistor is large so that the signal generator approximates a constant current source.

This method is rapid and flexible. Many curves can be obtained with different collector-voltages in a fraction of the time required for the corresponding d-c or a-c measurements. Also, any irregularities in the α_{ce} characteristic, such as multiple peaks, discontinuities, and oscillations are immediately in evidence.

α Versus Frequency Measurements. In the active region the emitter current in a conventional point-contact transistor is primarily hole flow into the *n*-type semiconductor, and the collector current is chiefly electron flow out of the semiconductor. Current gain results when an emitter-injected hole arrives at the collector rectifying the barrier and liberates several electrons. The time required for the holes to travel from the emitter to the collector limits the frequency response of the device. This effect is analogous to transit-time effects in vacuum tubes.

The frequency response can be measured in terms of (1) alpha versus frequency curves or (2) in terms of pulse response. Alpha versus frequency measurements can be obtained by point-by-point or sweep techniques. Fig. 7 indicates a method of obtaining point-by-point data with a variable-frequency signal generator. Care must be taken to insure that the inductance and capacitance components maintain their proper reactance magnitudes as the frequency is varied.

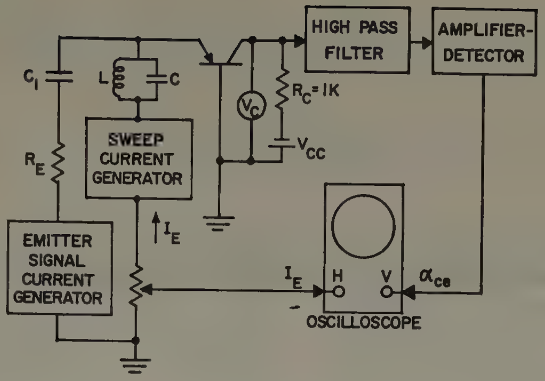
The sweep method indicated in Fig. 8 can also be used to measure alpha versus frequency for selected values of I_E. A figure of merit, the alpha-cutoff frequency, f_{co}, can be obtained from the alpha versus frequency curve. This frequency is the one where alpha is 3 db below its low-frequency value.

Pulse Response Measurements. Application of a pulse to the input and observation of the rise and fall times in the output is an alternative method of studying the frequency response of a device or circuit. Fig. 9 shows a typical pulse response characteristic. The output pulse is divided into intervals as follows:

1. Ohmic Delay—the time between the application of the input pulse and the time when the output pulse attains 10 per cent of its final maximum amplitude.
2. Rise Time—the time duration during which the output pulse is increasing from 10 to 90 per cent of its maximum average amplitude.
3. Storage Time—the time between the end of the input pulse and the time when the output pulse has decreased to 90 per cent of its maximum average amplitude.
4. Fall Time—the time duration during which the output pulse is decreasing from 90 to 10 per cent of its maximum average amplitude.

After a pulse of emitter current is applied to a point-contact transistor, holes diffuse from the emitter to the collector and many paths of varying length are followed. Consequently, the collector current response to an applied pulse of emitter current is not instantaneous. Also, immediately after an emitter pulse is applied and before the first holes arrive at the collector, a small increase in collector current is often observed. This component of the collector output waveform is called the "ohmic feed through" or "ohmic delay." It is produced by the voltage-divider action of the applied pulse across the emitter and base resistances. When the emitter current is suddenly terminated, the holes in transit take different lengths of time to reach the collector resulting in a definite fall time.

The rise and fall times can be calculated using Region II equivalent circuits, and these calculations correlate well with measured values of alpha-cutoff frequency. Ohmic delay and storage time cannot be easily calculated, and considerable variation can occur from one transistor to another. Storage time depends on the extent to which the transistor is driven into the current saturation region (Region III) and also on the duration of the input pulse. The storage time decreases with the amplitude and duration of the input pulse.



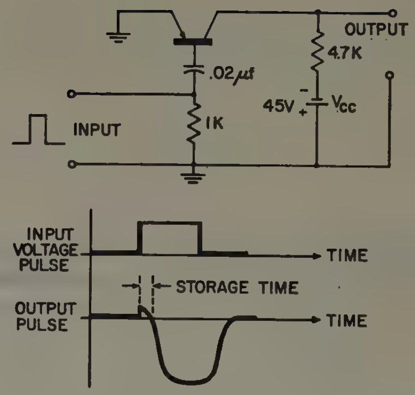
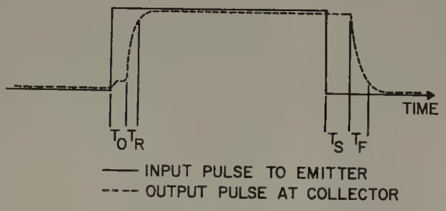


Fig. 8 (left). A sweep method of measuring α_{ce} versus I_E. Fig. 11 (right). Circuit diagram and waveforms for measuring storage time



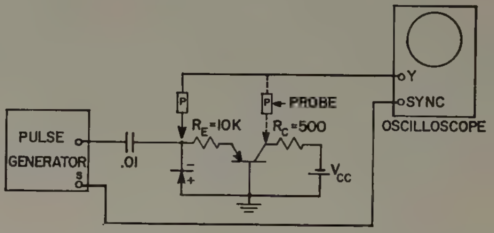


Fig. 9 (left). Pulse response: T_O=ohmic delay; T_R=rise time; T_F=fall time; T_S=storage time. Fig. 10 (right). Circuit for measuring pulse response. Typical operating conditions: $V_{CC}=-15$ volts; pulse width=4 microseconds; pulse amplitude=10 volts; pulse rise time=0.01 microsecond; pulse repetition frequency=5,000 cps

A method of measuring pulse response is indicated in Fig. 10. The diode clamps the base of the emitter square wave at ground potential. Resistor, R_E, is large compared to the input resistance so that the signal generator approximates a constant current source. Current limiting resistor, R_C, must be small so that it will not appreciably affect the frequency response of the device under test.

Another circuit which is frequently used to measure the storage time is shown in Fig. 11. In the absence of an input pulse, the transistor is in the current saturation region with unity saturation ($I_E=I_C$). The input pulse repetition rate is sufficiently low to insure that the density of minority carriers has built up to a constant value. The amplitude of the input pulse must be sufficient to drive the transistor to cutoff.

The storage time in an actual switching circuit does not necessarily correspond to the value measured in the above circuit for three reasons: (1) the transistor is not always completely saturated, (2) the turn-off pulses may differ in various circuits, and (3) the time that the transistor has been in the high-current condition depends on circuit and pulse arrangements.

Precautions. Visual display using an oscilloscope permits rapid measurements with an accuracy of about 5 per cent provided certain precautions are taken with respect to display bandwidth, repetition rate, and terminations.

1. *Display Bandwidth.* The test circuit and oscilloscope must have sufficient frequency response to pass many harmonics of the repetition rate, if a faithful reproduction of the alpha-versus-operating-point or alpha-versus-frequency curves is to be observed. In general, the display bandwidth will be determined by the fastest rise or fall time of the characteristic to be displayed. In most cases, the display bandwidth, BW, will be adequate if: $BW=2/t$, where t is the fastest rise or fall time to be observed. Use of a sine-wave sweep and display of both the forward and reverse traces permits one to check for adequate bandwidth. Insufficient bandwidth is revealed by hysteresis-like separation of the two traces.
2. *Repetition Rate.* Repetition rates less than about 25 cps will produce flicker and will result in operator fatigue and measurement inaccuracies. The maximum repetition rate limit is governed by display bandwidth requirements and frequency response characteristics. A low rate (33 cps) will minimize inaccuracies caused by inadequate display bandwidth and circuit frequency response.
3. *Terminations.* Terminations for the transistor and measuring circuit must be known and constant over the frequency band of interest. Also, instability may result if suitable resistance is not provided in series with the bias sources, particularly in the case of short-circuit unstable point-contact transistors.

TYPICAL MEASUREMENT RESULTS AND SPECIFICATIONS

Table I establishes a set of reference values for the recommended measurements. These reference numbers are based on a typical manufacturer's specifications and a series of measurements on about 20 transistor units tested from each of three different manufacturers. A set of circuit designer's specifications also is included representing the values desired for a typical specific application.

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Correction of Frequency Errors in Wattmeters

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MOST commercial wattmeters have a guaranteed limit of error of 1/4 per cent of full scale deflection on frequencies up to 133 cycles per second, but due to inherent errors this accuracy is not maintained at higher frequencies or with very low power factors. The errors referred to may be attributed to two things: the self-reactance of the voltage circuit, and the mutual reactance between the voltage coil and the current windings.

The indication of a wattmeter at a particular frequency depends upon the product of the currents in the two wattmeter circuits and the cosine of the phase angle between them. Fig. 1 is a phasor diagram which interprets the wattmeter operation on alternating current. The true power being measured is

$$P=EI\cos\theta \qquad (1)$$

where E is the voltage impressed across the voltage circuit, I is the current in the current circuit, and θ is the phase angle between E and I. θ is taken negative for lagging power factors and positive for leading.

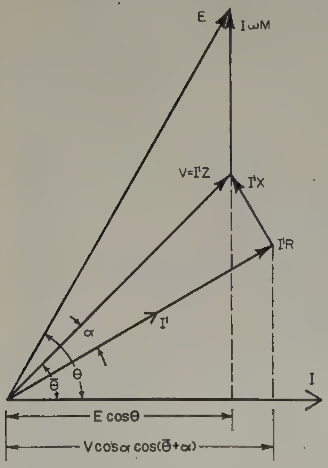
The effect of the mutual reactance between the two wattmeter circuits is to induce a voltage into the voltage circuit. This voltage is represented by the phasor $I\omega M$ and is in quadrature with the current I.

The current I' flowing through the voltage circuit lags the voltage by the the voltage circuit impedance, angle α. Therefore, the wattmeter indication is

$$W=I\,I'R\cos(\bar{\theta}+\alpha) \qquad (2)$$

From Fig. 1

$$E\underline{/\theta}=I'Z\underline{/\bar{\theta}}+I\omega M\underline{/-90^\circ} \qquad (3)$$



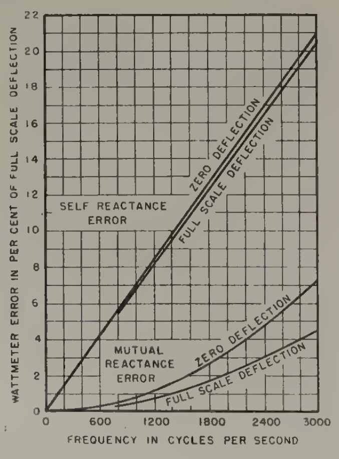


Fig. 1 (left). Voltage phasor diagram which indicates the operation of a wattmeter on alternating current. Fig. 2 (right). Curves of the frequency errors as a function of frequency for a Weston Model 310 low-power-factor wattmeter when used on the 75-volt range with rated voltage and current. Rating: 75 volts, 2.5/5 amperes, 37.5/75 watts

Multiplying equation 3 by the quantity $I\cos\alpha\underline{/\alpha}$ and taking the real part gives

$$EI\cos\alpha\cos(\theta+\alpha)=I\,I'R\cos(\bar{\theta}+\alpha)+I^2\omega M\cos\alpha\cos(\alpha-90^\circ) \qquad (4)$$

Comparing equations 2 and 4 shows the wattmeter indication to be

$$W=EI\cos\alpha\cos(\theta+\alpha)-I^2\omega M\sin\alpha\cos\alpha \qquad (5)$$

Equation 5 is an expression for the indication of a wattmeter on alternating current in which the effect of the mutual reactance has been isolated as a single term.

It is possible to correct wattmeter readings for the error due to the mutual reactance by adding a correction term, ΔW, to the wattmeter reading, W, which gives an adjusted reading

$$W'=W+\Delta W \qquad (6)$$

If W' is the wattmeter reading corrected for the effect of the mutual reactance it follows from equation 5 that

$$W'=EI\cos\alpha\cos(\theta+\alpha) \qquad (7)$$

and

$$\Delta W=I^2\omega M\sin\alpha\cos\alpha \qquad (8)$$

Because α is a small angle the expression for ΔW may be simplified to the form

$$\Delta W=0.11fMI^2\alpha \qquad (9)$$

where

f = the frequency in cycles per second
M = the mutual inductance between the current windings and the voltage coil expressed in henries
I = the current in the current circuit expressed in amperes
α = the phase angle of the voltage circuit self impedance expressed in decimal parts of a degree

When an instrument is connected for up-scale deflection, M is negative at the lower part of the scale and positive at the upper.

Fig. 2 compares the two frequency errors. The mutual reactance error varies as the square of the frequency, whereas the voltage circuit self-reactance error is proportional only to the first power of the frequency. This fact emphasizes the importance of correcting for the mutual reactance error when measurements are made at higher frequencies.

The error in indication caused by the mutual reactance between the two circuits of a wattmeter is given by equation 9. Wattmeter readings corrected for the mutual reactance error in this way then may be corrected for the voltage circuit self-reactance error by the usual methods.

Digest of paper 53-295, "Correction of Frequency Errors in Wattmeters," recommended by the AIEE Committee on Instruments and Measurements and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Summer General Meeting, Atlantic City, N. J., June 15–19, 1953. Published in AIEE *Communication and Electronics*, November 1953, pp. 679–82.

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Electric Circuit Models of the Nuclear Reactor

GABRIEL KRON
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AS THE FIRST large-scale industrial application of nuclear energy appears to be at present the generation of electric power, the electric power engineer is again being pressed by circumstances outside his control to get acquainted with a new physical science; namely, nucleonics and quantum mechanics. Three decades ago a similar situation confronted the electric power engineer when the arrival of radio forced him to study electronics and electromagnetic wave theory.

One such contact with the nuclear engineer exists already in the form of an electric circuit model for the wave equations of Schrödinger.[1] These equations play the same basic role in quantum mechanics and nucleonics that the field equations of Maxwell do in radio and electronics. The familiar concepts of natural frequencies of an electric circuit and the distribution of potentials in a circuit replace the eigen-value and eigen-function concepts of the physicist, customarily wrapped in the language of Hermite and other polynomials.

The present article establishes another contact between the electric power engineer and the nuclear engineer. A set of electric circuit models, or equivalent circuits, are established for the partial differential equations representing the diffusion of neutrons in a nuclear reactor of arbitrary shape. The well-known equations of diffusions may be expressed in any arbitrary curvilinear co-ordinate system along one, two, or three spatial dimensions. The variable energy of neutrons is represented in the model either more exactly as a fourth dimension, or approximately as a parameter of the multigroup theory. The variation of neutrons in time is introduced also as an additional dimension. Of course, any combination of spatial, energy, and time dimensions may be assumed as desired.

The electric circuit model of a reactor is analogous to an electric power transmission network and it gives a visual picture, greatly simplified of course, of several of the processes that take place in a reactor. Each generator (impressed junction current) represents a generation of neutrons by fission. The loads (impedance to ground) stand for the absorption of neutrons by the materials in the reactor, while the flow of electric current along the transmission network itself represents the diffusion of neutrons (neutron current) from point to point within the reactor. The absolute potential at every junction is equal to the neutrons of some particular energy appearing at that point of space.

The 1-dimensional circuit model has been used successfully throughout the last 6 years for the calculation of various types of nuclear reactors with spherical symmetry. The 2- and higher-dimensional circuits, however, could not be put to use until recently for two reasons:

1. The inadequacy and inexactness of all existing d-c and a-c network analyzers.
2. Lack of any analytical method to solve extensive 2-dimensional electric networks quickly and in an organized manner.

Recently the author has succeeded in developing a highly efficient method of solving physical systems in general and electric networks in particular, possessing thousands of variables, by means of already available high-speed digital computers.[2] The new method consists of tearing the given network (physical systems) apart into several smaller networks and solving, by finding the inverse matrix, each subdivision separately. The component solutions may afterward be interconnected to give the solution of the original large network. The remaining work consists of solving for the comparatively few number of variables appearing at the cuts. The latter solution may be accomplished, if necessary, by further tearing apart the cuts themselves.

The impedance matrices of cores, reflectors, and blankets with a large variety of compositions may be interconnected with a comparatively small amount of labor. Control problems involving movable or variable parts become amenable to more exact and still not too lengthy analysis.

In an actual electric network the electric charges are bodily transported from one portion of the network to another. When a network represents a nuclear reactor, then the motion of electric charges represents the motion of neutrons. The three basic concepts of a network, namely, voltage e, current i, and impedance z (or admittance y) correspond to neutron flux nv, (where n is the number of neutrons and v their velocity), neutrons current I, and cross-section Σ, respectively.

In nuclear reactor calculations it is necessary to account for all neutrons from their instant of birth by fission to their final expiration by leakage or absorption. That is, for each part, as core or reflector, etc., and for the entire reactor, at all instants the following equality must be satisfied:

$$\Sigma \text{ source} = \Sigma \text{ absorption} + \Sigma \text{ leakage}$$

It is interesting that in an electric circuit model the conservation of neutrons is satisfied at all instants because of Kirchhoff's laws.

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2. A Set of Principles to Interconnect the Solutions of Physical Systems, **Gabriel Kron.** *Journal of Applied Physics*, New York, N. Y., vol. 24, July 1953, pp. 965–980.

Digest of paper **54-199**, "Electric Circuit Models of the Nuclear Reactor," recommended by the AIEE Committee on Nucleonics and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Summer and Pacific General Meeting, Los Angeles, Calif., June 21–25, 1954. Published in AIEE *Communication and Electronics*, July 1954, pp. 259–65.

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Application of Toll Dialing in Pennsylvania

A. L. CHARNY

THE BELL SYSTEM companies have installed elaborate instrumentalities for operator dialing of long-distance calls and have initiated several trials of customers dialing such calls. Under this plan, a connection is established by means of the operator's or the customer's dial to any point in the United States without the assistance of intermediate operators. Two of the prerequisites for a successful operation of this nature, a nation-wide numbering plan for the customers' telephones and a system of switching centers, are discussed from the standpoint of their application in Pennsylvania.

The existing numbering plans were dictated by the economies of local dialing and differ widely among themselves depending on the size and the past history of the central offices. For customer dialing it is necessary to adopt a uniform plan as a future objective and to set up a program for attaining it in a reasonable time. Under this plan, known as the *2–5* numbering plan, the telephone number consists of two letters and five digits; the two letters are the initial two of the central office name, the next digit is part of the central office code, and the last four digits are the telephone number of the customer. It is also required that all names be taken from a standard list of about 300 names which are repeated as many times as necessary. It is hoped that these names will eventually become familiar to telephone users.

The framework for uniform numbering has been established in Pennsylvania by dividing the state into four numbering plan areas each containing approximately 350 offices. Every office will eventually be assigned a standard name, with each telephone in an area having a unique *2–5* number. To date, 60 per cent of all telephones in Pennsylvania are numbered on this basis, and 20 per cent of the offices have been assigned standard names.

In manual practice, toll switching points are equipped with through switchboards at which operators make the necessary interconnections. In automatic practice, large concentrations of equipment, using crossbar switches and complex common control apparatus, are provided to perform the interconnection and to route the calls to their destinations. Equipment of this type has been designated as the Number *4* toll crossbar system. Switching centers using the *4*-type equipment have already been established at Philadelphia in 1943, at Pittsburgh in 1951, and at Scranton in 1953. Plans have been completed for an installation at Harrisburg before the end of 1955. In addition to these four centers, it is planned to establish simplified switching systems at Warren and Altoona about 1957.

Fig. 1 shows the proposed arrangement of the toll centers in Pennsylvania from the standpoint of interconnection for the handling of long-distance traffic. Each toll center "homes" on one of the switching centers so that in the general case a call is carried from the calling point to its toll center, then to its home switching center, and through intermediate switching centers to its destination.

The application of nation-wide dialing in Pennsylvania has required a large amount of modification of existing equipment. Out of the total of $35 million that has been invested in Pennsylvania thus far to achieve approximately 60-per-cent operator dialing, $12 million are invested in the Number *4* switching systems; the remaining $23 million have been spent to modify the outward switchboards, to install incoming automatic equipments, and to provide the necessary circuit terminations. Additional investments of the same order of magnitude will be required to complete the operator dialing program. Nation-wide dialing by Bell of Pa. customers was initiated at the Valley central office, Turtle Creek, Pa., at the end of 1953 on a trial basis. Installations on a restricted basis are in progess at Philadelphia and Pittsburgh and others are contemplated in the near future.

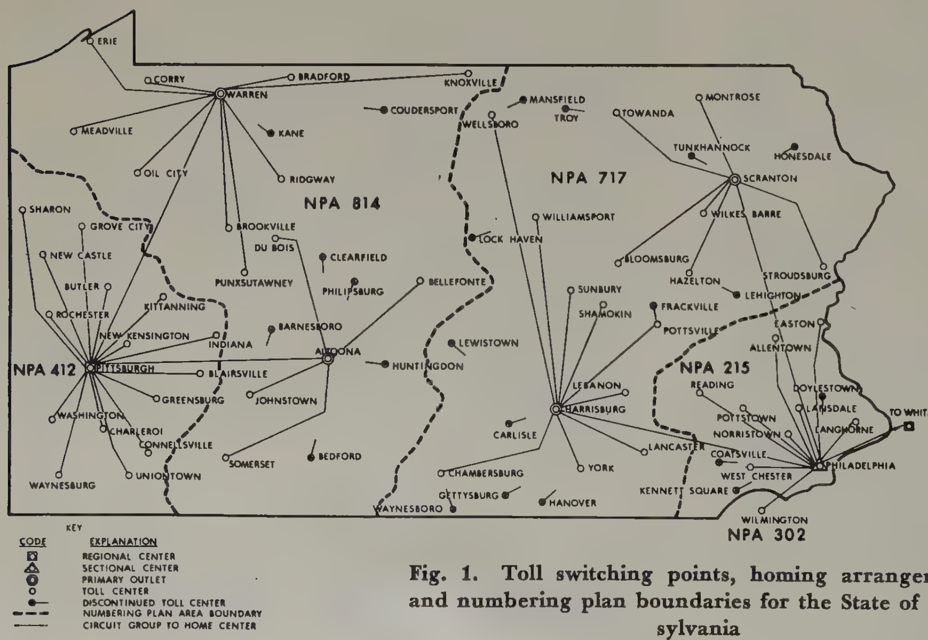

Fig. 1. Toll switching points, homing arrangements, and numbering plan boundaries for the State of Pennsylvania

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Digest of paper 54-273, "Application of Toll Dialing in Pennsylvania," recommended by the AIEE Committee on Communication Switching Systems and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Summer and Pacific General Meeting, Los Angeles, Calif., June 21–25, 1954. Scheduled for publication in AIEE *Communication and Electronics*, 1954.

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Magnetostriction and Domain Structure of Materials for Use in Low-Noise Equipment

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Magnetostriction is discussed from the viewpoint of the problem of audio noise in inductive equipment. Certain special problems which must be considered in the application of domain theory to experimental data such as those obtained from crystal-oriented 3-per-cent silicon-iron alloys are taken up. In addition, experimental methods and results are also described.

THIS article is an attempt to survey in simple terms the range of phenomena called "magnetostriction," having in mind the engineer who, faced with the problem of audio noise in inductive equipment, wants to know "What about magnetostriction?" It also points out some rather special problems in connection with the application of domain theory to such experimental data as are obtained on crystal-oriented 3-per-cent silicon-iron alloys. Experimental methods and results are described briefly.

In view of these objectives, the discussion is limited to the longitudinal magnetostriction.[1] An acquaintance with the domain theory of ferromagnetism and the properties and underlying theory of the commercial crystal-oriented 3-per-cent silicon-iron alloys will be assumed.[2,3]

The control of undesirable noise and vibrations of inductive equipment which are partly caused by the magnetostriction of the core material is an important problem. In transformers, for example, the need to meet audio noise maxima represents a real limiting factor in reducing their size—and cost in some cases.

FACTORS DETERMINING LONGITUDINAL MAGNETOSTRICTION

IF it is desired to lower the magnetostriction of a material one might first list the factors that determine its magnitude. A separation under the following three headings appears most appropriate for this purpose:

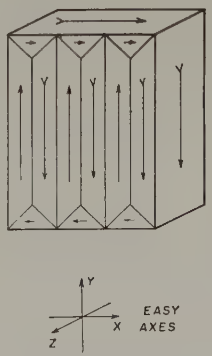
1. Crystal structure.
2. Composition.
3. Domain structure.

The first two are fixed for a given sample or part of a sample. The last is sensitive to the shape of the sample and to its state of stress.

Crystal Structure. A single crystal is characterized by certain symmetry properties. Hence, the dependence of the magnetostrictive strain λ on the direction of the magnetic flux density B in the crystal might be expected to have similar symmetry properties. For instance, if one magnetizes along the x-axis of a cubic crystal and a certain strain is observed along the y-axis, then renaming $x \rightarrow y$ and $y \rightarrow z$, which is equivalent to rotating the crystal, should make no difference in the observed strain. In order to observe this crystallographic dependence of the magnetostriction it is necessary, however, first to eliminate the effect of domain structure. Fig. 1 shows a typical domain structure of a single crystal. It is clear that in this case the x, y, and z axes are not equivalent. However, it is possible to make measurements of only the crystallographic dependence of magnetostriction by taking into account a known, simple domain anisotropy of the sample. Such measurements were made by W. J. Carr, Jr.,[4] for silicon-iron alloys. He used single crystal disks with strain gauges mounted along a suitable crystallographic axis. By rotating these disks in a strong uniform magnetic field they stay saturated along the field direction. Hence one really deals with the case of a single domain. The length of the disk will change as the magnetization changes its angle with respect to the crystallographic axis, and the direction the strain is measured.

The result of these experiments can be expressed in the form of two magnetostriction constants belonging to the material. These are shown in the graph of Fig. 2 for a range of silicon-iron alloys, which is taken from Carr.[4] Knowing these constants h_1 and h_2 it is possible, to a good approximation, to calculate the change in length along any crystallographic direction for a given change in flux density, provided the initial and final domain distribution is known.

Composition. The dependence on composition of these



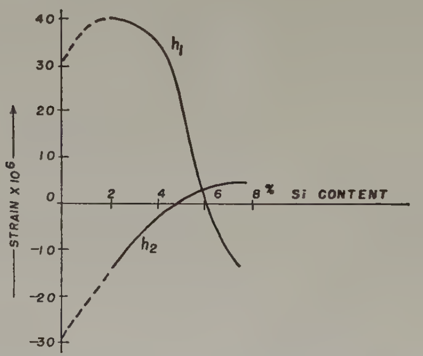


Fig. 1 (left). Schematic representation of a typical domain structure of a slab of Si-Fe with easy axes as shown. Fig. 2 (right). Magnetostriction constants h_1 and h_2 of Si-Fe alloys

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Revised text of a conference paper presented at the AIEE Winter General Meeting, New York, N. Y., January 18–22, 1954, and recommended for publication by the AIEE Committee on Basic Sciences.

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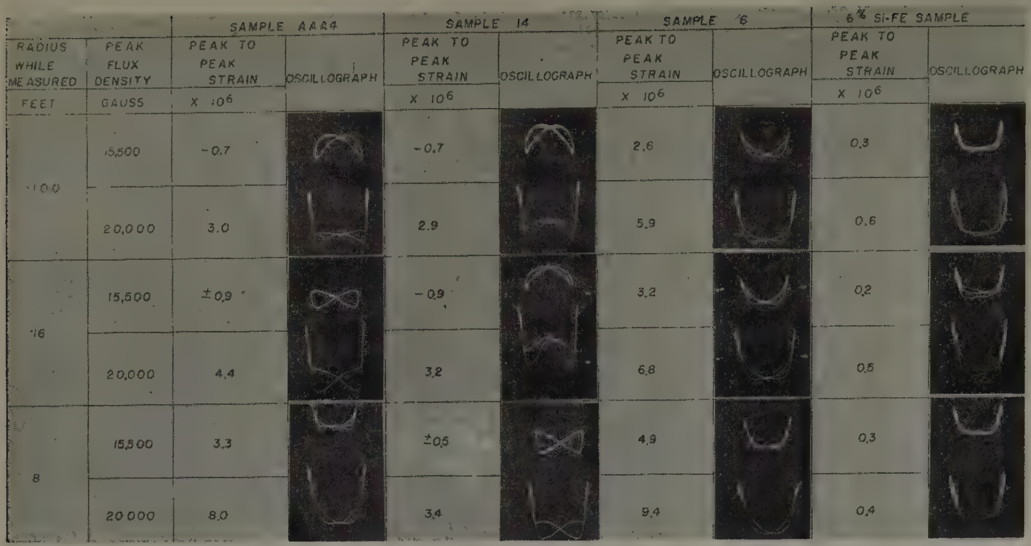


		SAMPLE AAA4		SAMPLE 14		SAMPLE 6		6% SI-FE SAMPLE	
RADIUS WHILE MEASURED	PEAK FLUX DENSITY	PEAK TO PEAK STRAIN	OSCILLOGRAPH	PEAK TO PEAK STRAIN	OSCILLOGRAPH	PEAK TO PEAK STRAIN	OSCILLOGRAPH	PEAK TO PEAK STRAIN	OSCILLOGRAPH
FEET	GAUSS	X 10⁶		X 10⁶		X 10⁶		X 10⁶	
100	15,500	-0.7		-0.7		2.6		0.3	
	20,000	3.0		2.9		5.9		0.6	
16	15,500	±0.9		-0.9		3.2		0.2	
	20,000	4.4		3.2		6.8		0.5	
8	15,500	3.3		±0.5		4.9		0.3	
	20000	8.0		3.4		9.4		0.4	

Fig. 3. Magnetostriction curve of 0.014- by 1.2- by 10-inch samples under 60-cycle excitation. Samples AAA4, 14, and 6 are oriented 3-per-cent Si-Fe. All samples were annealed flat, but measured at the curvatures shown

magnetostriction constants is apparent from Fig. 2. If both h_1 and h_2 were to go through zero at the identical composition, one would have a material without any first order magnetostriction. In the silicon-iron alloy system one can come fairly close to this condition at a silicon content of about 6 per cent. Such an alloy would have several desirable properties. Its resistivity is about twice as high as the 3-per-cent silicon-iron alloy, its crystalline anisotropy lower by more than one third. In addition, it might be possible to raise the knee of its magnetization curve to a high value by heat treatment in a magnetic field, to which this alloy responds favorably. Unfortunately, this alloy is as brittle as glass at room temperature—but it can be worked hot, and it does have low magnetostriction, independent of stress, as shown in the last pattern of Fig. 3.

Domain Structure. In investigating the effect of crystal structure on the magnetostriction the domain structure was reduced to a single domain. Magnetization changes were produced by domain rotation only. In practical applications of soft magnetic materials one is, at least in the silicon-iron alloys, mainly interested in the easier domain wall motion process of magnetization. In this case, magnetostrictive strains are the result of more or less complicated changes in domain patterns. The ease with which these patterns can change also makes the observed magnetostrictive strains extremely sensitive to the state of stress of the sample. So much so, as a matter of fact, that the measurement of the magnetostriction under these circumstances becomes a real problem.

MEASUREMENT OF MAGNETOSTRICTION IN STRAIN SENSITIVE SAMPLES

Because of the difficulty of making valid magnetostriction measurements under these circumstances a short digression into the measuring techniques may be of value. Briggs Gettys of the General Electric Company has been largely responsible for the development of a very neat way of measuring the magnetostrictive strain of so-called Epstein strip samples (25 by 3 by 0.035 cms). The sensing device in this equipment is simply a phonograph pickup. This measures the strain of the central 3 inches of the sample, between the point of clamping of the strip and the point where the stylus makes contact, as shown in Fig. 4.

As the sensitivity of phonograph pickups is not highly directional, probably having a discrimination of no better than 10 to 1 between any two directions, it is of great importance that the motion of the sample is solely magnetostrictive. This is accomplished by the presence of a thin oil film between the sample and a smooth base plate. The weights on the sample simply assure that the film will really be thin, because the vertical restraining force per unit area of the sample, i.e., the pressure P, averaged over the width W of a strip assumed to be infinitely long, is given by

$$P=\frac{\eta v W^2}{64a^3}$$

where

η = viscosity of the oil
a = thickness of film
W = width of sample
v = velocity of the sample

A thin oil film will therefore effectively prevent vertical motion at power frequencies, and makes this method of measurement possible. With this equipment magnetostriction measurements can be made rapidly, and with ease, even by semiskilled personnel. However, frequent expert attention and checks on the calibration of the pickup are necessary.

The output of this instrument can be seen on an oscilloscope, where the magnetostriction λ appears on the y-axis, as a function of the flux density B along the x-axis. Measurements are made at a magnetizing frequency of 60 cycles, producing 120 magnetostriction cycles per second. The samples can be measured flat, or by the use of jigs with curved base plates, bent to radii of 16 and 8 feet respectively. The peak-to-peak values of λ and B appear on suitable meters.

Similar results can be obtained by the use of strain gauges with magnetizing cycles lasting 2 to 3 minutes—

a second method used in the General Electric laboratory, which is a modification of one first described by J. E. Goldman.[5] Here it is very important that the strain gauges are glued on without producing any stresses. This is not possible in an absolute sense, but the use of an epon resin cement without solvent in conjunction with narrow gauges made of thin paper, is good enough for many purposes. The sample must be kept from changing its curvature, because the two gauges used in this method cannot be mounted perfectly symmetrical with respect to the neutral axis of the sample, and hence do not always provide the complete compensation intended.

EXPERIMENTAL RESULTS

Some typical results that have been obtained with the phonograph pickup equipment are shown in Fig. 4. A considerable range of magnitudes and a strong response to the curvature can be observed.

With the strain gauge equipment, it is easy to make measurements under longitudinal tension. Such measurements show that when starting with a flat sample having a high positive magnetostriction like sample no. *6* of Fig. 3, it is changed under tension to the low peak-to-peak magnetostriction pattern with its initial negative portion, similar to that exhibited by sample no. *14* when flat. The tension necessary to accomplish such a change in any oriented silicon-iron sample never exceeds a few hundred pounds per square inch.

From the mass of experimental evidence several points stand out:

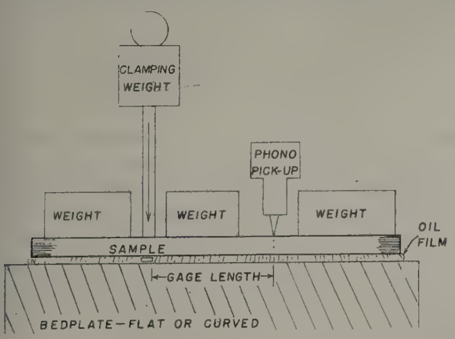
1. The magnetostriction of different samples, from nominally identical batches of material varies considerably.
2. Many samples show a very low magnetostriction value compared to what can be calculated on the basis of a random domain distribution and the known magnetostriction constant h_1, assuming essentially single crystal properties. Such a calculation would predict a peak-to-peak magnetostriction value of about 25×10^{-6} at saturation, instead of frequently observed values of as low as 3×10^{-6}.
3. Magnetostriction curves with low peak-to-peak values have negative portions at flux densities below 16,000 gauss.
4. Under tensile stresses of a few hundred pounds per square inch the high magnetostriction samples change to low magnetostriction samples. Corresponding increases in magnetostriction are caused by compressive stresses of the same order of magnitude produced by bending, or by gluing paper on the surface of samples, using a cement that contracts the paper on drying.

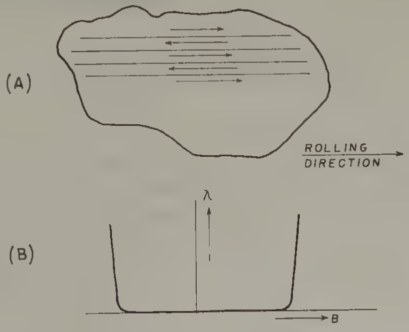
DISCUSSION

It is possible to give at least a partial explanation of the observations listed, by assigning a "reasonable" domain structure to the samples. In the discussion which follows, it should be kept in mind that the three "easy" directions, along which the domains will be magnetized except in high external fields, are the [100], [010], and [001] directions. The [100] direction in effect may be taken to coincide with the rolling direction in the oriented silicon-iron samples under consideration.

1. To account for the low magnetostriction values of flat externally unstressed samples, one postulates that 3-per-cent silicon-iron crystal-oriented (110), [100] material, consists of domains oriented with the rolling direction. This almost ideal case is shown in Fig. 5*A*. When such a sample is magnetized in the rolling direction, the domain pattern changes largely by 180° wall motions which involve no change in length. If the rolling direction does not exactly coincide with the [100] direction, some domain rotation can be expected at high fields, giving rise to a positive magnetostrictive strain. The resultant magnetostriction curve might look like that shown in Fig. 5*B*.
2. To account for the effect of compression along the rolling direction in raising the magnetostriction, it must be noted that domains magnetized along the [010] and [001] directions, rather than in the [100] direction, reduce the length along the rolling direction by about 40×10^{-6} for the volume involved. Hence, without an external field, compression applied to a sample such as shown in Fig. 5*B* will change its domain pattern to one containing an increasing volume of domains magnetized at right angles to the rolling direction. When such a sample is subsequently magnetized in the rolling direction, the required 90° wall motions give rise to a positive magnetostrictive strain of 40×10^{-6} for the domains affected.

The question arises whether this change in domain pattern, and the increase in magnetization caused by it under stress, is a reasonable one at the observed stresses.





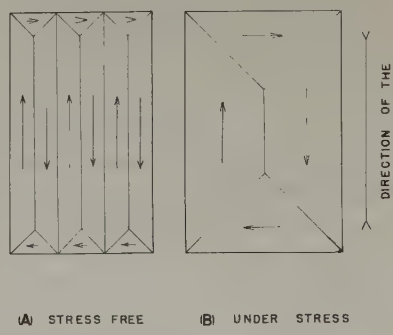


Fig. 4 (left). Magnetostriction measurement equipment for 60-cycle excitation, using a phonograph pickup developed by B. Gettys
Fig. 5 (center). Proposed domain pattern in highly crystal-oriented 3-per-cent Si-Fe of low magnetostriction, with a corresponding magnetostriction curve. Fig. 6 (right). Effect of compressive stress on the equilibrium domain pattern for an idealized case

To decide this accurately one would have to know both the domain pattern and the stress distribution. In the absence of this information an idealized case which is similar, and where more information is available, can be examined profitably. This is the example of a domain pattern worked out by Kittel.[6] Applicable to an iron cube, its results should be of the same order of magnitude as those on these samples. The free energy of the equilibrium pattern in the absence of external stresses shown in Fig. 6*A* is about 50 ergs per cm^3. A stress of 10 kilograms per cm^2, which is less than 150 pounds per inch^2 implies a strain energy about equal to the 50 ergs per cm^3. One would therefore expect the equilibrium pattern to be altered considerably, perhaps to that shown in Fig. 6*B*. If this iron cube is magnetized in the vertical direction, it is clear from Fig. 6 that the magnetostrictive strain of pattern *A* would be rather small, while that of the pattern *B* would be three times as large.

The effect of tension on reducing the magnetostriction of samples, which initially show a high magnetostriction, is explainable along the same lines. The tensile stress aligns the domains, so that a larger percentage of the volume is taken up by domains in the [100] direction.

Bending, of course, produces both tension and compression. For a sample of initially low magnetostriction, this will always result in an increase in magnetostriction, because if the domains are already aligned additional tensile stresses cannot decrease the magnetostriction any further in the half of the sample which is under tension. Only the compressed half of the sample can change—and its magnetostriction being increased, the average for the whole sample will increase up to a maximum peak-to-peak magnetostriction value of about 20×10^{-6} at saturation.

3. The initial negative portion of the magnetostriction curves is not explained as easily. J. E. Goldman[7] has suggested that is due to the formation of closure domains during the magnetization of crystallites whose [100] direction makes a small angle with the plane of the sample. No quantitative proof of this hypothesis is given, however, and no pictures showing the formation of such closure domains during magnetization have been published, as far as is known to the author.

4. Finally, it would be consistent to conclude that large variations in magnetostriction of externally strain-free and otherwise similar* samples may be largely a matter of residual internal or surface stresses.

MAGNETOSTRICTIVE EFFECTS DUE TO MATERIAL UTILIZATION

If the results reported, and their interpretation, describe all the essential features of magnetostrictive behavior, it should be clear what steps must be taken to obtain low magnetostriction in inductive equipment. Not only will the raw "stock" material have to be selected, but the conditions under which it is finally used—after handling and assembly—will determine what its magnetostriction will be. Among these conditions this article showed semiquantitatively the importance of stress for the magnetostriction of oriented silicon-iron.

Empirically, Burgwin[8] demonstrated the beneficial effect of tension in such alloys. Where compressive stresses predominate in an application and are unavoidable, possibly a change to a different material might be indicated.

In conclusion, so far as applying the results of this study to design are concerned, let it be emphasized that not all audio noise problems of inductive equipment can be solved by reducing the magnetostriction of the magnetic core material. Only when the major contribution to the total noise is caused by magnetostrictive strains will their reduction have any appreciable effect.

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* Similar, for instance, with respect to their dimensions, 60-cycle watt loss and degree of preferred orientation.

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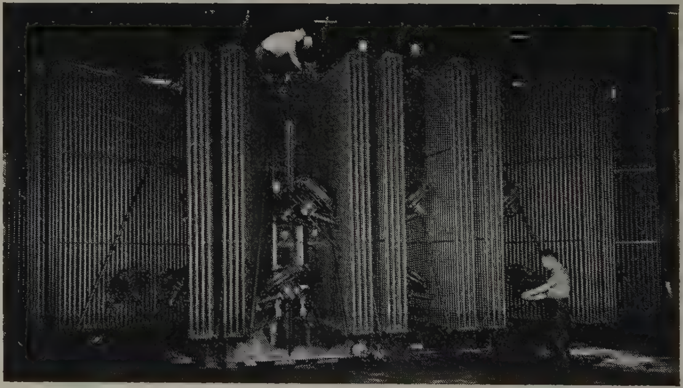
Largest Self-Cooled Transformer



Largest self-cooled transformer ever built by the General Electric Company is shown during final assembly at the plant, Pittsfield, Mass.

The huge unit, which weighs 392,000 pounds full-assembled, will soon be put into service at the Jersey Central Power and Light Company's high-voltage transmission system at the Raritan River Station at Sayreville, N. J. The transformer has the capacity to supply enough electricity for a city of 200,000 people.

The unit's self-cooled rating is 84,000 kva, but this can be increased to 140,000 kva by putting its 46 high-velocity cooling fans into operation. The unit will be used to step up generated power from 18,000 to 115,000 volts for transmission purposes.

Stripped of radiators, fans, and other accessories, the transformer was shipped to Sayreville upright in its own 1-piece tank on a drop-frame flat car especially designed for transformer shipment.

Time-Scale and Gain Influence on Servo Performance

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THE MATHEMATICAL synthesis problem in linear servomechanism design is to find the description of the system when the desired output response to a given input is specified. The desired output, however, is often defined as the "best" that can be obtained, where the word "best" has several connotations which include fastest transient response, minimum overshoot, and minimum tendency toward persistent oscillations. It is possible to apply suitable criteria and select the "optimum" response in a normalized time scale.

In two previous papers,[1,2] the authors applied this procedure to a variety of systems up to the eighth order. Normalized transfer-function coefficients which gave rise to optimum transient responses were determined experimentally, and tabulated as "standard forms." A unitary criterion, the minimum integral of time-multiplied absolute-value of error (ITAE), defined as $\int_0^\infty t|e|\,dt$, was used. Other integral criteria, including the integral of squared error (ISE), defined as $\int_0^\infty e^2 dt$, were also investigated.

In practical servomechanism synthesis, however, more often than not the number or range of system parameters available to the designer for adjustment is inadequate, and the adjustment for optimum response cannot be independent of the time scale or the static loop gain. Under these circumstances, the implications of applying a unitary criterion are less obvious and the character of an optimum response is more obscure.

Qualitatively, except for considerations of servomechanism response to noise, there is no room to doubt that a contracted time scale always represents an improvement in transient performance. Quantitatively, however, it is doubtful whether or not halving the time scale of the response improves the performance by exactly a factor of 2.

Fig. 1 illustrates the variation of the ISE and ITAE criteria applied to the step-function responses of servomechanisms with the transfer function

$$\frac{C(p)}{R(p)}=\frac{\omega_0^2}{p^2+2\zeta\omega_0 p+\omega_0^2} \tag{1}$$

as the natural frequency ω_0 is changed. The ISE criterion curve is a hyperbola and illustrates the species of criterion which halves its value when the natural frequency is doubled (or the time scale is halved). On the other hand, the ITAE demonstrates the evaluation of relative merit as discussed, which shows a decreasing proportional benefit as the natural frequency is continually increased.

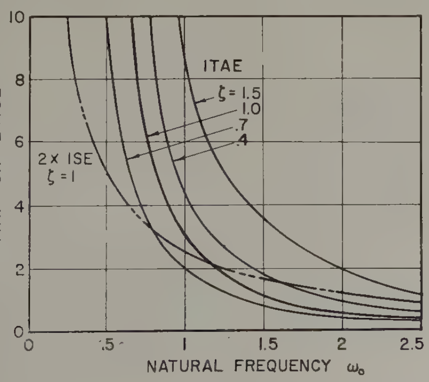

Fig. 1. The effect of relative time scale or system natural frequency upon the value of the ITAE and ISE criteria, second-order systems

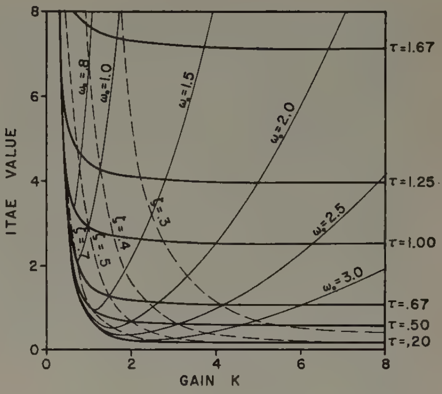

Fig. 2. The variation of the ITAE criterion value with open-loop gain and time constant, simple second-order systems

In some simple servomechanisms, the static loop gain may be the only system parameter which can be conveniently adjusted. For example, such a system would be one with the closed-loop transfer function

$$\frac{C(p)}{R(p)}=\frac{K}{\tau p^2+p+K} \tag{2}$$

where τ is a fixed time constant.

The ITAE criterion value, as a function of K, is shown in Fig. 2. As the gain is increased, the ITAE value decreases. It is evident, however, that a point of diminishing returns exists, as evidenced by the knee in each curve. Contours of constant natural frequency and damping ratio are overlayed on Fig. 2 for reference purposes.

The effects of time scale and static gain variations upon third-order servomechanisms have been investigated, and are essentially similar to those found in second-order systems. When used in the selection of optimum gain or time scale, the ITAE criterion appears to retain the advantages of selectivity and reliability which were noted when it was applied to the selection of normalized transfer function coefficients.

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Operating Load Tapchanging Transformers

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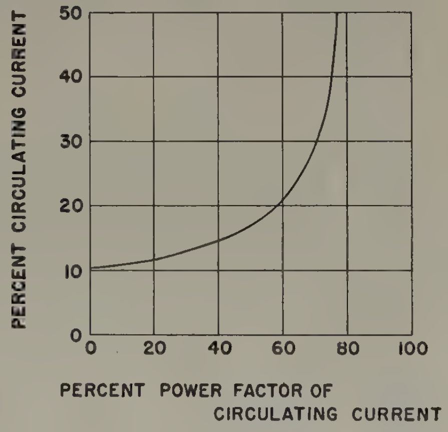
When TRANSFORMERS with automatic load tapchanging are operated in parallel, a method of preventing excessive circulating current is required. Some of the methods used are extremely complex requiring additional equipment as well as the use of control connections between units.

The combination of resistance compensation to produce constant voltage at the load center together with reverse reactance compensation to limit the circulating current between units is applicable to many circuits where more complicated means of parallel operation are now used. This system has the advantage of requiring no additional equipment and no use of control connections between units.

When a load tapchanging transformer is equipped with automatic control including a line drop compensator, the only changes necessary to secure parallel operation are to reverse the connections of the reactance element of the compensator and change the settings of resistance and reactance elements of the compensator. In practice the reactance element of the compensator is adjusted so as to limit the circulating current to the required value. The resistance element of the compensator is adjusted to compensate for the line drop and for the voltage drop produced by reversing the reactance element.

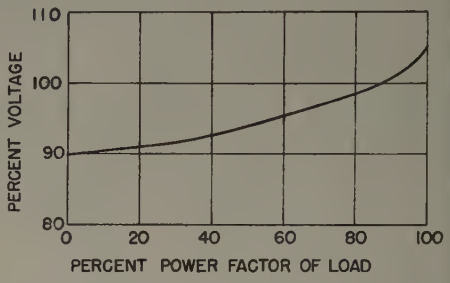
Fig. 1. Variation of maximum circulating current with its power factor



The maximum value of circulating current which can flow between units is a function of the sum of the reactance drop in the line in the transformer to the point of paralleling with other transformers and the reactance element of the compensator. The sum of these two reactances may be termed the effective reactance. The value of circulating current is also proportional to the bandwidth of the voltage control relay. The value of the circulating current depends upon its power factor, typical variations being shown in Fig. 1. It is evident from this figure that a low power factor circulating current is desirable in order to keep the circulating current at a low value. This condition is generally met. Increasing the setting of the resistance element of the compensator tends to increase the circulating current, but when the power factor of the circulating current is low, its effect is small.

The value of the circulating current can be calculated from the bandwidth, the power factor of the circulating current, the resistance and reactance of the line, and the settings of the reactance and resistance elements of the line drop compensator.

Fig. 2. Typical voltage variation with power factor



The resistance which is effective in controlling the voltage at the load is equal to the difference between the resistance drop in the line and the resistance element of the line drop compensator. A setting for the resistance compensator is selected which will produce constant load center voltage corresponding to a given effective reactance, load power factor, and line resistance.

If the load power factor does not change, it is possible to maintain constant voltage at the load center. Fig. 2 shows how the voltage at the load center varies with the power factor of the load. This curve shows the variation at full load. The variation in voltage from the no-load value is approximately proportional to the load. Consequently, if the power factor variation occurs only at light loads, conditions are favorable for maintaining nearly constant voltage at the load center.

The voltage which is held at the load center can be calculated from the values of resistance and reactance of the line, resistance and reactance of the compensator, and the magnitude and power factor of the load.

The relation developed shows that satisfactory performance in limiting circulating current between units and maintaining voltage at the load center can be secured in many cases. Best performance is obtained when the power factor of the load is substantially constant and the power factor of the circulating current is low.

Digest of paper 54-205, "Parallel Operation of Load Ratio Control Transformers Using Reverse Reactance Compensation," recommended by the AIEE Committee on Transformers and approved by the AIEE Committee on Technical Operation for presentation at the AIEE Summer and Pacific General Meeting, Los Angeles, June 21–25, 1954. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1954.

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A New Approach to the Problem of Higher Distribution Voltages

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With a view to keeping a vast network system abreast of the times, it is necessary that the question of the distribution voltage be examined on the broad basis of a fundamental plan rather than on the peculiarity of isolated loads.

AT THE time the 120/208-volt a-c automatic network was adopted by one of the Consolidated Edison predecessor companies in 1922, the objective was to compete on equal terms with the 3-wire 120/240-volt Edison d-c system which was then the largest supply of electricity in Manhattan. The original installation had a total connected transformer capacity of around 100 megavolt-amperes and represented almost the entire Manhattan 60-cycle distribution load.

By way of comparison, the present a-c network in Manhattan is divided into 12 areas and has a total connected transformer capacity of approximately 2,000 megavolt-amperes. Of this amount, approximately 1,600 megavolt-amperes are installed south of 60th Street within an area of 8 square miles. The total demand on the Consolidated Edison networks is of the order of 1,750 megawatts and represents approximately 60 per cent of the total system demand. Individual buildings with a demand in the 4,000- to 8,000-kw range are increasing in numbers and the 120/208-volt system in many cases is becoming uneconomical for the supplier as well as the user.

Looking into the future and with a view to keeping such a vast network system abreast of the times, it became essential that the question of the distribution voltage be examined on the broad basis of a fundamental plan rather than on the peculiarity of isolated loads. In recent years, throughout the country, commercial buildings have been served at voltages in the zone of 416 to 550 volts, but these installations merely indicate a trend of opinion where large isolated loads are involved.

An over-all plan offering a service voltage other than 120/208 volts, however, would have to satisfy these basic requirements to warrant its integration into the present Consolidated Edison System:

1. It should be broadly adaptable to any proportion of future load growth.
2. It should be compatible with any reasonable future expansion or contraction of the 120/208-volt system.
3. It should not force premature retirement of the components of the 120/208-volt system.
4. It should have equal or better economy of supply than the 120/208-volt system.
5. It should have equal or better acceptance by and economy to the power users.

A group of papers[1–6] presents the results of extensive studies resulting in the decision by the Consolidated Edison Company to offer 265/460 volts for certain categories of load.

REVIEW OF NETWORK PRINCIPLES AND TRENDS OF PRACTICE

Conventional General Network. An automatic low-voltage general network is usually in the form of Fig. 1. The secondary mains are usually 120/208 volts, and are gridded throughout the area served by the particular network. In such a general network, it is presumed that the total load is made up of a multitude of small loads, more or less uniformly distributed. The transformers are in single units, more or less uniformly located, and are connected to the network through automatic network protectors. The primary feeders are interlaced in such a manner that when one is lost to service due to a fault or for maintenance, the transformers lost are scattered over the area so that the remaining transformers share the overload fairly uniformly. The loss of one primary is termed "first contingency."

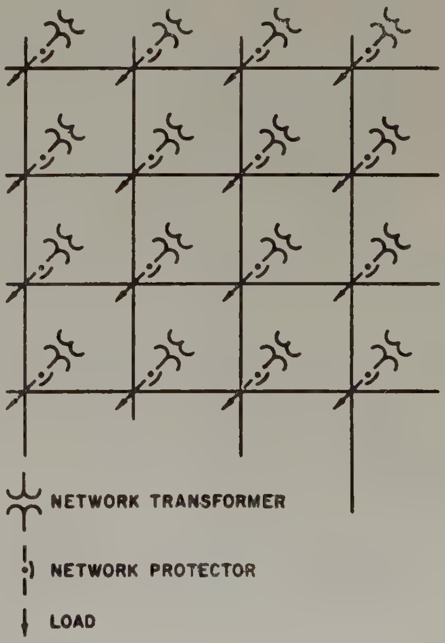

Fig. 1. Simplified conventional secondary network layout

One of eleven papers in special publication S-66, recommended by the AIEE Transmission and Distribution and Industrial Power Systems Committees and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Fall General Meeting, Chicago, Ill., October 11–15, 1954.

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The authors would like to thank the engineers engaged in this development for their helpful contributions and hearty co-operation.

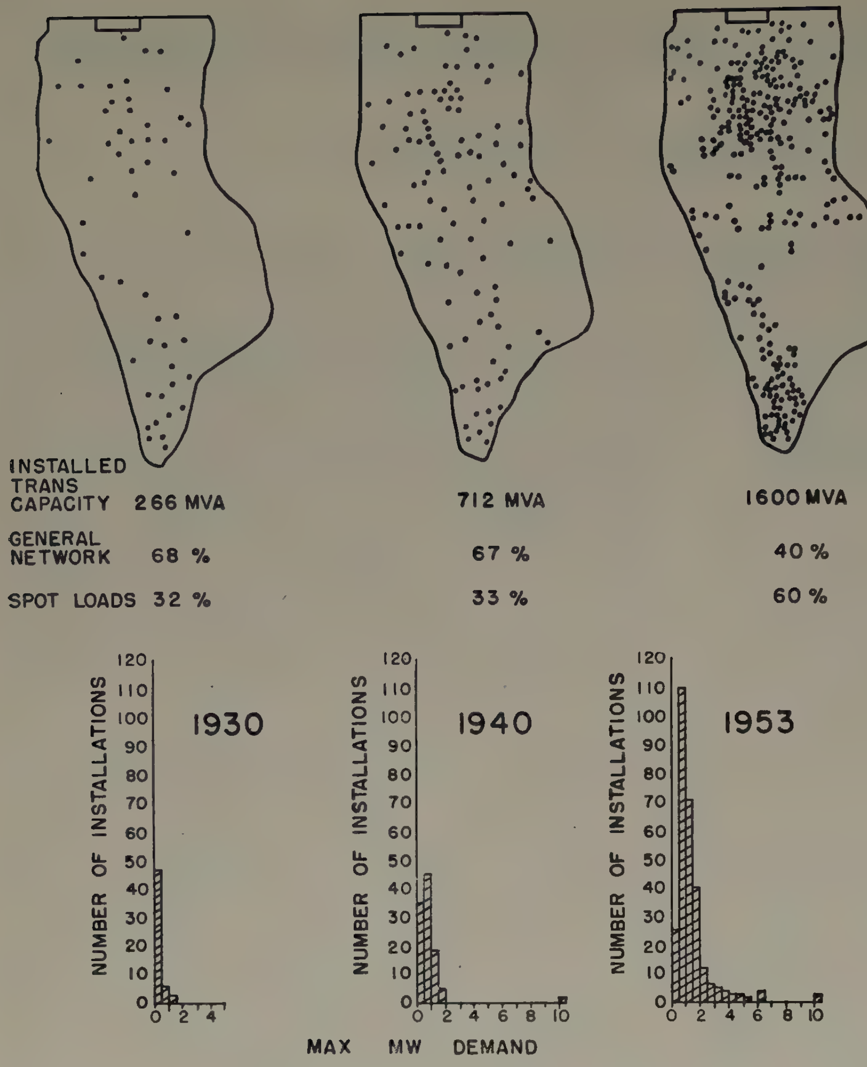

Fig. 2. Growth of spot loads in Manhattan

The subsequent loss of a second primary is termed "second contingency." The network system may be designed for either one or two contingencies, depending on circumstances. The present Consolidated Edison network is designed on the basis of second contingency.

During contingencies, the load on the remaining transformers is allowed to go to 125 to 130 per cent of rating, depending on circumstances. The secondary mains must be capable of accepting the overload output of the transformers within their own overload capabilities. Generally the transformers are located at intersections; hence the mains usually run in four directions from the transformers. Sometimes the mains in two of the directions are overloaded more than in the other two directions for a given feeder contingency, but during another feeder contingency the other pair of mains may take most of the overload. These circumstances, plus the vagaries of load growth, make it desirable to use uniform-sized conductors in the secondary mains.

In laying out networks, it is necessary as in any distribution system to make the usual compromises between the present and future load requirements. Since the size of the secondary mains is determined by the transformer size, it is very important that the transformer size be chosen on a long-range basis so that wholesale transformer replacements and reinforcement of mains are not required by load growth.

For conditions encountered by the Consolidated Edison Company, a minimum transformer size of 500 kva has been found most economical in the long run. Likewise, two groups of eight 4/0 copper conductors, with each group in a duct, forming two 3-phase 4-wire 120/208-volt circuits have been found most suitable for the network grid.

A number of standard patterns of transformer location and secondary mains have been devised to provide the most economical service for the various block layouts and stages of load growth. These patterns cover general network loadings of about 4,000 to 40,000 kva per square mile. Usually 500-kva transformers are installed at the outset, and the standard patterns furnish a guide for their placement in terms of the load density served. In general, the secondary mains do not require substantial reinforcement as the load increases.

Departures from General Networks. In the foregoing section, it will be noted that no standard patterns have been laid out for load densities in excess of 40,000 kva per square mile. However, the average load density in several of the networks is of the order of 200,000 kva per square mile. This seeming inconsistency is due to the fact that so far the portion of the total load which is the agglomeration of a large number of small loads has not substantially exceeded 40,000 kva per square mile.

What has happened is that in high load density areas, large commercial buildings have accounted for a large percentage of the load growth. These buildings have been served most economically by the use of "multitransformer spot installations." There are groups of from three to six transformers of 500 or 1,000 kva each, connected to a common 120/208-volt bus through network protectors. Each transformer is supplied by a separate primary feeder. The loss of two primary feeders is presumed possible at peak load and the remaining transformers must carry the load within their overload capabilities. This results in the capabilities of multitransformer spots presented in Table I, which has been based on second contingency conditions.

Where loads in excess of 5,000 kva are served at the same general premises, it may be done by two or more spot networks. A number of such installations take the

Table I. Capabilities of Multitransformer Spots

Number of Transformers in Spot Network	Load Capability of Spot Network, Kva: 500-Kva Transformer	Load Capability of Spot Network, Kva: 1,000-Kva Transformer
3	650	1,300
4	1,300	2,600
5	1,950	3,900
6	2,600	5,200

form of "vertical networks" wherein multitransformer spots are installed in the upper stories of tall buildings.

The multitransformer spots are usually tied into the general network, and where there are sizable loads close to the spots, the spots afford some support to the general network. The converse cannot generally be depended upon, and possible assistance from the general network is ignored for the larger spots.

In general, for individual load increments equal to or exceeding 650 kva, a multitransformer spot is installed. Below 650 kva, the general network may or may not be able to absorb a load increment, by adding one or two single transformer vaults, depending upon the existing facilities. The design engineer must decide, on the basis of present loadings and growth forecasts, whether to increase the capability of the general network in the vicinity of the new load (by altering the pattern of single transformer installations) or install a multitransformer spot network.

Increasing Dominance of Multitransformer Spots. Over the 30 years' use of the 120/208-volt network, there has been not only a large increase of load but also a shift in the character of the load. Fig. 2 shows graphically the rapid increase in multitransformer installations in Manhattan below 60th Street and the progressively increasing proportion of the total load represented by them. This trend is expected to continue with new building constructions and modernization of old buildings. Air conditioning and improved lighting of buildings at present are believed to be only a fraction of what they will be some years hence.

THE PROBLEM

It is considered that the trend toward larger individual loads will continue. Most of the large new loads can use a higher voltage than 120/208 more economically, because of reduced building wiring costs and the lesser cost of motors and controls. Consequently, consideration was given to the use of a distribution voltage of the order of 460 volts.

Many engineering factors must be studied to determine the long-term feasibility of 460 volts. It is not sufficient merely to examine individual cases on their individual merits. To do so could result in a hodgepodge of different distribution voltages, leading to confusion, and possibly dissipating the anticipated savings of the higher voltage. The problem must be solved on the basis of a fundamental plan, seeking answers to these questions:

1. What should the higher voltage be?
2. What is the order of cost saving realizable?
3. What form should the new higher voltage distribution system take?
4. Should there be interconnection between the higher voltage system and the present 120/208-volt system?
5. What would be the most economical policy to adopt with respect to service of new loads?
6. What would be the effect of the adoption of an additional distribution voltage on other elements of the power system, such as substations and primary feeders?

ANALYSIS

The answers to the foregoing questions are interrelated, and require a tremendous amount of work to obtain. The companion papers give the detailed results of the studies; in this article only the broad aspects are considered.

Selection of 460 Volts. While some consideration was given to 2,400 volts, it was evident that the voltage selected should be within the limits of the 600-volt class of apparatus. In this class there is a broad coverage by standard apparatus of both power supply and user equipment in the switchgear, transformer, motor, control, and lighting categories. Finally 265/460 volts was selected as the best compromise between the features of the other candidates: 240/416 and 332/575. A powerful argument for the 265/460 was the fact that this voltage can be used for the operation of standard motors and for general lighting now that 265-volt fluorescent lighting is available and approved by City Code for such purposes.

Cost Saving of 265/460 Volts over 120/208 Volts. The saving to supply a given load varies considerably with circumstances and the magnitude of the load. Essentially, it represents a reduction in the over-all cost of transformer capacity, vaults, protectors, busses, and connections made possible by the installation of fewer transformers of larger rating, namely 2,000 kva.

A study of several vault installations has indicated savings in favor of 460 volts ranging all the way from 10 to 37 per cent. It is too early, however, to draw any conclusions as to the expected average saving per kilowatt of demand. Considerable savings are also indicated in the users' premises.

Spot Networks with Multiple Radial Secondaries Selected for New 460-Volt System. The studies showed that a 460-volt

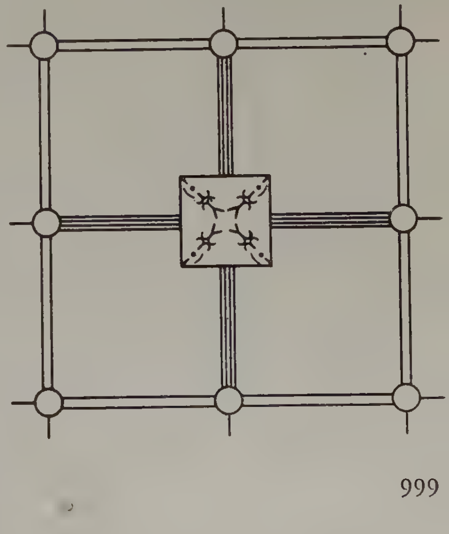

Fig. 3. Simplified layout of spot-network/radial system for $1^1/_2$-block reach for uniform density service. All mains have limiters at each intersection

general network was about 35 per cent less costly than a 208-volt general network for uniform load densities. Corresponding studies showed that noninterconnected 460-volt spots could reach out and render service to uniformly distributed loads at less cost than a 460-volt general network. The system is shown in Fig. 3. The reliability of the 460-volt spots using fewer transformer units for a given load than the 208-volt spots will at least equal the reliability of the 208-volt spots. The secondary mains are made essentially interruption-free by the use of multiple circuits, protected by limiters.

The illustrative subarea supply system shown in Fig. 3 is the form the system would take if each of the connected load units were relatively small (say 100 to 500 kva) and uniformly distributed. With this character of load, this system has at the higher load densities a cost advantage over a 460-volt conventional network feeding the same load with both types of systems ideally designed. However, there are three factors which work against attaining ideal economy on a conventional network. These factors are:

1. The necessity of securing an economic balance between transformer size, transformer spacing, and secondary conductor size. This balance is determined by the load density, and with changing load density a balanced optimum design cannot be maintained.
2. The network cannot be designed for the average load density of the entire network area. The load density of subareas within the network may vary as much as 10 to 1. To provide for loss of transformer capacity from feeder outages requires that lightly loaded subareas adjacent to heavily loaded subareas be reinforced considerably beyond their own load requirements.
3. A conventional network is not suited to the supply of spot loads which may range up to 10,000 kva or more.

None of these factors apply to the spot/radial system with the same economic force as to the network system. Thus, while idealized cost studies show only a moderate saving for the spot/radial system, the actual savings are expected to be substantial.

Supply of 120/208-Volt Services. At the present time there is no alternative than to assume that 120-volt service will always be required throughout the Consolidated Edison service areas regardless of load density. Also, that there will be a normal load growth of the existing 120/208-volt system. However, based on historical data, it seems reasonable to assume that a substantial amount of the load increase would be served at 460 volts. The interest shown by the power users in the 460-volt system during the last few months warrants this assumption. It is believed that this higher voltage will probably be confined to the main arteries of commerce, thus not embracing the entire service area for years to come.

In those areas where 460-volt service is available, the question is immediately posed as to how to handle the two service voltages. At present, no ties between the two systems are contemplated. Such ties would present problems of transformer phase-angle relationships, phase position of generating sources, network protector operation, and voltage regulation when the two systems are supplied from different generating stations. There also appears to be little economic gain available from such ties.

The over-all network system will consist, therefore, of the basic 120/208 network areas upon which a number of relatively small 460-volt spot/radial areas will eventually be superimposed. Whether or not it will be practical under certain conditions to sever blocks of 120/208-volt load from the general network and serve them from the 460-volt spots will be determined by experience.

Size of New Loads Served at 460 Volts. It is obviously impractical to offer 460 volts for all services regardless of size and location. To facilitate an orderly and economical growth, 265/460-volt service is presently restricted for the supply to existing or new buildings when warranted by the magnitude or location of the load or other physical conditions. When such service is supplied to a new building, however, no service of other characteristics will be introduced into the building either initially or in the future.

Presently, the lower limit below which it is uneconomical to supply 460-volt service is of the order of 2,800-kva demand. As the commercial areas become dotted with spot nuclei, service to smaller loads will probably be offered, and rendered by "reaching out" from the spots.

EFFECT OF 460-VOLT DISTRIBUTION ON LONG-RANGE SYSTEM PLANNING

Prospectively, the decision to adopt a 460-volt distribution system will exert a profound effect on future system planning. This effect will extend from the generating stations to the substations and to the primary feeders.

The interrelation between the distribution system and the remainder of the system arises from three main causes:

1. The transformer sizes are increased from the prevailing 500- and 1,000-kva values to 2,000 kva.
2. With the spot/radial 460-volt system, the number of transformer locations will be much smaller for a given kilovolt-ampere of load served.
3. System requirements and economics limit the capacity of network area substations in Manhattan to about 180 megawatts. This limitation will require splitdowns of network areas as the substations reach their maximum capability.

The introduction within the network areas of spot/radial nuclei supplied directly from the generating station will provide load relief to the substations and affect the long-range planning of substation facilities.

The effect of the changes in the distribution on system planning is a large subject, and a detailed discussion is out of keeping with the subject of this article. However, as there is an opportunity for further savings in over-all system cost, a brief discussion is in order.

It has been shown[7] that 13.8 kv was too low a voltage for bulk-power transmission even for the short distances encountered in Manhattan; another paper[8] corroborated this situation for Chicago. The Consolidated Edison Company has built three 69/13.8-kv 180-megawatts area substations in Manhattan, each with a possible ultimate capacity of 200 megawatts. These substations have effected substantial savings in the cost of transporting power from the generator terminals to the load centers, whence the power is taken via 13.8-kv feeders to the individual network transformers.

With 120/208-volt distribution the maximum transformer size, because of network protector limitations, is 1,000 kva. The majority of the transformers are of the 500-kva rating and they are at scattered locations. With this situation, the economical primary feeder voltage is in the zone of 13.8 to 27 kv. With the 460-volt spot/radial system, a transformer size of 2,000 kva is economical. The plan contemplates spots of capacities up to 10,000-kva firm capacity, which means fewer transformer locations. The effect of these two factors, larger transformer size and fewer transformer locations, is to raise the economic primary feeder voltage.

As a result of extensive studies Consolidated Edison has decided to proceed with the installation of 69-kv primary distribution feeders from the East River Generating Station to certain areas of Manhattan. These feeders will provide bulk power distribution directly from the generating station to new large 460-volt spot/radial nuclei when it is economical to do so and, at the same time, through a 69/13.8-kv transformation will pick up portions of existing 120/208-volt network areas presently supplied from 13-kv sources. This development will provide relief for existing area substations and other generating stations which would otherwise reach their rated capability in the near future. It is important, therefore, that cognizance be taken of the fact that radical changes in distribution practice can back up into other parts of the system, and permit further cost savings to be realized.

SUMMARY

1. Where the user preference voltage is principally 120/208 volts, and fairly uniformly distributed, the general network is an economical and reliable distribution system.
2. When large spot loads are encountered in an established 120/208-volt district, they can usually be supplied at 265/460 volts at a substantial saving.
3. The most economical form of 265/460-volt system is the multitransformer spot network system, with multiple radial services to the loads.
4. The larger transformer sizes and fewer locations characterizing 460-volt distribution will permit further savings in the primary supply system.

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Sources and Properties of Electrical Noise

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Natural noises such as "Johnson noise," shot noise, and contact noise are reviewed. Following a discussion of noise measurement, the man-made noises such as interference signals, power hum, impulse noise, and quantizing noise are considered.

ELECTRICAL NOISE may be divided into two main classifications: that provided by nature, and that which is man-made. The first group is principally associated with the inherent corpuscular structure of electricity. The fact that electrical phenomena are based on discrete charged particles shows up in any sufficiently fine scale examination, as a grainy property leading to noise.

A representative example is the "Johnson noise,"[1–8] named for its discoverer, J. B. Johnson, 1927, and also called "resistance noise," "thermal noise," or "Brownian motion of electrons." Conductors function as such because of an ever-present cloud of free electrons inside; these electrons are in thermal equilibrium with the molecules of the substance and hence are in rapid motion except when interrupted by collision with the molecules or more rarely with other electrons. The mean length of a path between successive collisions suffered by one electron at room temperature is 6×10^{-7} cm and the time between collisions is 6×10^{-14} second. A charge in motion constitutes an electric current so there is a superposition of a large num-

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ber of short pulses of current forming an aggregate which is observed as the noise phenomenon.

Two outstanding properties of the Johnson noise are that it is white and that it is Gaussian. By white, it is meant that its power spectrum is flat; that is, contributions to its mean power are uniformly distributed along the frequency scale. By Gaussian, it is meant that the instantaneous magnitude of the effect is distributed in accordance with the normal law of probability.

It should be explained that a truly white spectrum over all frequencies is a physical absurdity because if there is any power at all in any finite width of frequency range, an indefinite extension along the frequency scale of more power distributed with the same density would lead to an indefinitely large amount of total power from the source. This is similar to the ultraviolet catastrophe which troubled the investigators of "black body radiation" in the last part of the 19th century, and it will be recalled that it was to escape this catastrophe and incidentally to check experimental measurements that Max Planck invented the quantum concept underlying modern theoretical physics. To make an acceptable calculation of how the Johnson noise ultimately departs from whiteness does in fact require the use of quantum mechanics. Such theoretical studies have been made and the frequency at which the spectrum is down 3 db has been estimated to be of the order of 1.7×10^{13} cycles per second. This is far beyond the range which has as yet acquired any practical electrical interest, and hence for present purposes the whiteness may be taken as one of the unassailable premises; measuring circuits lose frequency response much sooner than the sources show any diminution. It may be noted also that the aforementioned model of Johnson noise consisting of an aggregate of practically independent current pulses of duration 6×10^{-14} second is thoroughly consistent with a flat spectrum up through the highest microwave frequencies as yet realized, and experiments have fully confirmed the flatness.

Given the uniform spectrum and a further assumption that classical statistical mechanics is adequate for the treatment of the Johnson noise in the frequency range of interest, it is quite simple to evaluate the power spectrum numerically and set up a satisfactory technique for all Johnson noise calculations in linear electric circuits. The theorem needed from statistical mechanics is the "equipartition principle" which assigns an average amount of energy $kT/2$ to every position or momentum co-ordinate which makes a quadratic contribution to the total energy of a complicated system. Here T is the absolute temperature and k is Boltzmann's gas constant, 1.37×10^{-23} joule per degree Kelvin, which is related to the average change in kinetic energy of a gas molecule per unit temperature change.

It is to be noted that the equipartition principle is independent of the size and shape of the particle to which the energy is assigned; it only depends on the fact that energy is proportional to the square of a velocity or displacement. Johnson noise has been previously referred to as arising from Brownian motion of electrons, and it is helpful to review the significant facts concerning Brownian motion discovered before Johnson measured thermal noise.[9–11] Brown was an English botanist who observed in 1828 an irregular motion of pollen on water. His first hypothesis was that of an elementary manifestation of living matter, but this was abandoned after the same motion was observed in inanimate specimens such as granite dust from an Egyptian sphinx. It was eventually demonstrated both experimentally and theoretically that the relatively enormous particles of dust were in fact sharing the kinetic energy of the molecules constituting the liquid in full accordance with the equipartition law.

In the case of the cloud of electrons the situation is quite analogous to that of the dust particles except that the electrons are relatively insignificant in size with respect to the molecules of the substance. The important fact from this point of view, however, is that it is not necessary to investigate the complicated system of many small flying electrons, but only to add one large molecule to the system, for example a capacitor across the terminals of the conductor. Specifically consider the conductor by Thevenin's theorem as a source of internal emf of power spectrum $\rho\, df$ (volts)^2 per cycles per second in series with resistance R. (At sufficiently low frequencies the reactance may be neglected.) Then connect a large capacitance C across the terminals. The mean energy stored in this capacitor is $CV^2/2$, where V^2 is the average squared voltage across the terminals. Since V is a variable which makes a quadratic contribution to the total energy, the equipartition principle says that

$$\frac{CV^2}{2}=\frac{kT}{2}$$

But from circuit theory, it may be calculated that

$$\frac{CV^2}{2}=\frac{C}{2}\int_0^{\infty}\frac{\rho\, df}{1+4\pi^2 f^2 C^2 R^2}$$

or, from equating the two expressions

$$kT=C\rho\left[\frac{1}{2\pi CR}\text{ arc tan } 2\pi CRf\right]_{f=0}^{f=\infty}=\frac{\rho}{4R}$$

and hence $\rho = 4kTR$, the now well-known expression for the spectral density of a Johnson noise source. It is seen that the value of C disappears in the expression for spectral density and that R does not affect the total energy. It was specified that C should be large in order to legitimize that part of the calculation which neglects internal reactance of the conductor. The essential contribution to the integral comes from the range of low frequencies at which such reactance is negligible if C is made large enough. The quantum-mechanical modification of this derivation substitutes a function of frequency for $kT/2$ and if C is then replaced by a tuned circuit the modified spectrum varying with frequency may be determined, but won't be treated here.

Once the spectral density is obtained, all calculations of Johnson noise power spectra in linear electric circuits become a matter of standard electric circuit theory. Independent noise generators can be inserted in series with each resistor and superposition applied, but a simplification easily derivable from the principle of conservation of energy permits the replacement of all Johnson noise sources in a 2-terminal network in passive circuits by a single source of spectral density $4kT$ times the real part of the impedance at the frequency in question. It also should be noted that spectral densities have been expressed thus far in terms of squared volts per cycles per second. The available power is obtained from division by $4R$ and is approximately 204 db below one watt for a bandwidth of one cycle per second at 20 C. A highly useful relative measure of the noise introduced by a transmission network is the "noise figure" defined as the ratio of available signal-to-noise power ratios at the input and output terminals.[12]

While on the subject of power spectra, it is appropriate to discuss also the case of shot noise in electron tubes. Consider the case of current saturation in which all electrons emitted from the cathode travel directly to the anode. Here the noise arises from the fact that the current from cathode to anode is not continuous but is composed of discrete arrivals of electronic charges. Assume that the anode circuit consists of a resistance R in parallel with a capacitance C. The current from the electron stream consists of electronic charges e arriving at the average rate γ per second but with the individual arrival times randomly distributed throughout a long time interval X. It is convenient to resolve the problem into a flight of the electron from cathode to anode of such short duration as not to affect frequency resolution in the range of interest. A consequent typical electron arrival at time τ suddenly delivering a charge e to the capacitor and discharge current in the resistor is

$$F(t-\tau)=\frac{e}{RC}\exp\left(-\frac{t-\tau}{RC}\right)$$

The actual phenomenon does not dissociate in this manner, but linearity of the system enables a resolution into the sum of fictitious component processes to be made. The total current in the resistor at time $\tau=X$ is the sum of νX such currents with the values of τ distributed at random throughout the interval X. Each component current may be regarded as drawn from an ensemble of functions $F(t-\tau)$ with the probability density function of τ equal to $1/X$. The average current for a large number of repetitions of the measurement at $t=X$ is the ensemble average of $F(t-\tau)$ multiplied by the number of components, that is

$$I_0=\bar{I}=\nu X\,\overline{F(t-\tau)}=\nu X\int_0^X\frac{e}{RC}\exp\left(-\frac{X-\tau}{RC}\right)\frac{d\tau}{X}=\nu e\left[1-\exp\frac{-X}{RC}\right]\rightarrow$$
$$\left.\nu e \text{ as } X\rightarrow\infty\right]$$

I_0 is the current read by d-c meter, and the power represented by the d-c part of the wave is proportional to $(\bar{I})^2$. The total power is proportional to the mean value of I^2. The noise power is proportional to the difference between $\overline{I^2}$ and $(\bar{I})^2$. Since it is known from statistical theory that the variances, or differences between the square of the mean and the mean square, for independent phenomena add directly to form the variance of the sum

$$\overline{I^2}-(\bar{I})^2=\nu X\{\overline{F^2(t-\tau)}-[\overline{F(t-\tau)}]^2\}=\nu X\,\overline{F^2(t-\tau)}-I_0^2/\nu X\rightarrow$$
$$\nu X\int_0^X\frac{e^2}{R^2C^2}\exp\left[-\frac{2(X-\tau)}{RC}\right]\frac{d\tau}{X}\text{ as }X\rightarrow\infty\rightarrow\frac{\nu e^2}{2RC}=\frac{eI_0}{2RC}$$

Now Norton's Theorem, used to represent the noise by an equivalent current generator of mean square current σdf in bandwidth df in parallel with capacitance C, must give

$$\frac{eI_0}{2RC}=\int_0^\infty\frac{\sigma df}{1+4\pi^2f^2R^2C^2}=\frac{\sigma}{4RC}$$

and hence

$$\sigma=2eI_0$$

which is the well-known expression for the spectrum of shot noise in a saturated diode at frequencies low compared with the reciprocal of the electronic transit time. The response of any desired linear network to shot noise can be found from this model by applying standard electric circuit theory. If a Thevenin's theorem model is preferred a voltage can be inserted with mean square $2eI_0df/4\pi^2f^2C^2$ in bandwidth df at f as a source in series with C. When the diode is operated below saturation current, the shot noise is reduced because the cloud of uncollected electrons now enters into the phenomena of conduction.[13]

A third kind of natural electrical noise of considerable importance is the so-called "contact noise" observed when current is transmitted across a boundary between two conductors and more recently as an unwelcome adjunct of current flow in semiconductors such as used in transistors. The present state of knowledge concerning contact noise is far from complete. A semiconductor may be regarded as an insulator with impurities. In a perfect insulator the electrons would be bound to their position in a lattice framework and hence not free to take part in current flow. Impurities may either add unbound electrons or absorb some of the bound electrons leaving unbound positively charged "holes." In either case carriers of electric current are available. Fluctuations in the density of these carriers cause the conductivity to vary and hence lead to noise when current is passed through the semiconductor. A similar noise is found in carbon microphones. The "flicker noise" in vacuum tubes associated with variation in cathode activity is a related phenomenon.[14]

A characteristic property of contact noise observed over a wide range of conditions is its $1/f$ spectrum—that is, a power spectrum which varies as the reciprocal of frequency. Measurements have shown this to hold fairly well from frequencies as low as 0.1 cycle per second to the megacycle range. If a $1/f$ spectrum is integrated from $f=f_1$ to $f=f_2$ to obtain the total noise power, a result proportional to $\log f_1-\log f_2$ is obtained which contains not only an incipient ultraviolet catastrophe but an infrared disaster as well. The $1/f$ law therefore cannot hold all the way down to zero frequency nor all the way up to infinity. The ultraviolet difficulty is avoided by more exact experimental work showing that the law is more nearly $f^{-1.2}$ than f^{-1}, but this only makes the situation worse as direct current is approached. Theoretical derivation of the $1/f$ law has not yet been achieved without great complexities both in the assumed model and the required calculations.[15–17] A further distinction possessed by contact noise has appeared in applications to transistor circuits in that equivalent circuit representations containing more than one noise generator must take account of correlation between these sources.[18]

With the exception of contact noise and related phe-

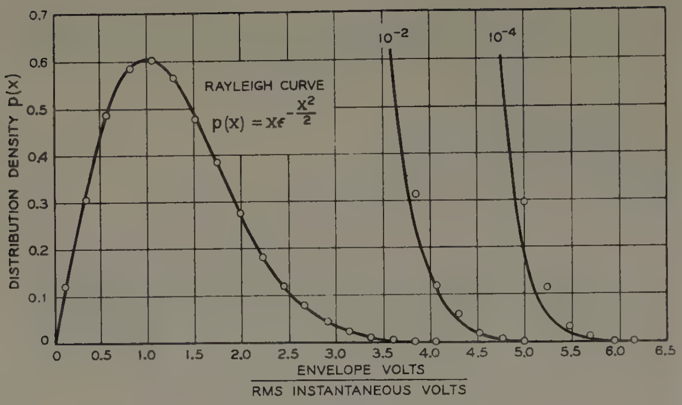

Fig. 1. Knudtzon's experimental data on the envelope distribution density of noise from gas tube

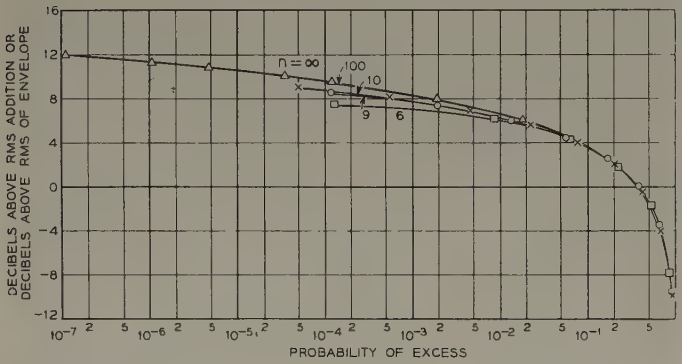

Fig. 2. Calculated envelope distribution density of sum of n sine waves with random phases

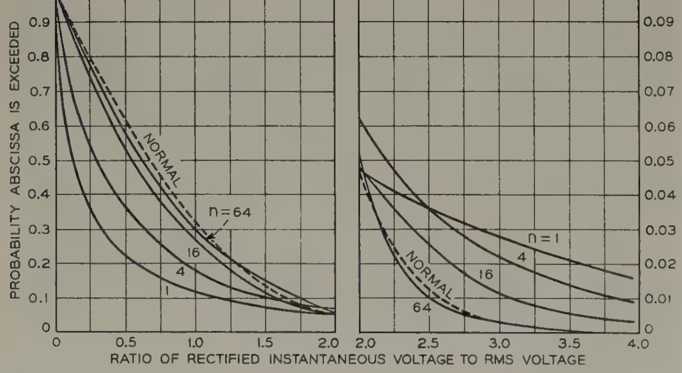

Fig. 3. Distribution of instantaneous voltage from sum of n speech waves

nomena, the noises mentioned so far follow the Gaussian law in magnitude distributions. This means that the probability density function $p(E)$ of the instantaneous value E has the form of the normal error function

$$p(E) = \frac{\exp(-E^2/2E_r^2)}{E_r\sqrt{2\pi}}$$

where E_r is the root-mean-square value. When multiplied by dE, $p(E)$ gives the probability that an instantaneous value selected at random falls in the range E to $E+dE$. This single relationship in itself is not sufficient to characterize a process as Gaussian. The multivariate density functions for magnitudes at specified time intervals apart must also follow the corresponding multidimensional normal error laws. That is, if $p_\tau(E_1, E_2)dE_1dE_2$ is the probability that the two values at instants of time τ seconds apart are in the ranges E_1 to E_1+dE_1 and E_2+dE_2 respectively, then

$$p_\tau(E_1, E_2) = \frac{1}{2\pi\sqrt{E_r^4 - E_\tau^4}} \exp \frac{-E_r^2(E_1^2+E_2^2)+2E_\tau^2E_1E_2}{2(E_r^4-E_\tau^4)}$$

where E_τ^2 is the average product of two values, τ seconds apart. Furthermore, the corresponding generalization must hold for $p_{\tau_1\tau_2}(E_1,E_2,E_3)$, etc.[19] The Gaussian distribution may be deduced as a consequence of the central limit theorem of statistical theory which states that the sum of a large number of independently distributed quantities must approach the normal, or Gaussian, distribution no matter what the individual distributions may be. The primary independent quantities here are the original impulses from which the noise wave is derived, and the number which contribute to a typical measurement is very large indeed. Experimental checks on thermal and shot noise have shown no reason to question the applicability of the Gaussian law. Contact and transistor noise may, however, exhibit non-Gaussian properties.

A comprehensive set of measurements on noise was made by N. Knudtzon at Massachusetts Institute of Technology in 1949.[20] An example is shown in Fig. 1. It is necessary to explain here that there are two common ways of expressing the Gaussian law for one variable—the instantaneous probability density given above, and the envelope probability density shown in Knudtzon's curve. The envelope, which is more appropriate for the narrow band case in which the midband frequency of the noise spectrum is large compared with the bandwidth, is the resultant amplitude function of sine and cosine oscillations having the midband frequency and independent Gaussian amplitude distributions. The probability density of the envelope is found by transforming the vector sum of horizontal and vertical Gaussian 1-variable distributions to polar-coordinates and averaging over the angle variable. The result is

$$p(x) = x \exp(-x^2/2)$$

where x is the ratio of envelope to rms and $p(x)dx$ is the probability that the value of x is in dx at x.

The Gaussian envelope density (sometimes called the Rayleigh distribution) shows a probability peak at the rms value and trails off rapidly at high magnitudes. There is however a finite probability of exceeding any specified value no matter how large. In practical calculations it is common to neglect all occurrences for which the probability is less than some arbitrarily small value. There is no clear-cut value at which this may be done. Knudtzon's data, Fig. 1, show the normal law followed up to 6.3 times the rms magnitude of the envelope, and there appears to be no reason for doubting that further verification is only a matter of sufficient sensitivity and linearity of apparatus as well as a sufficiently long time of observation. For most purposes, results will not be affected much if the chopping off is done at four or more times the rms, as indicated for example by earlier measurements made by Jansky.[21]

The fact that a Gaussian distribution may be obtained by combining a large number of independent non-Gaussian waves suggests convenient models for measurement and analysis of noise effects. For example a Gaussian noise of any desired spectrum can be approximated by adding sine waves of appropriate amplitude and frequency from independent oscillators. Fig. 2 shows the closeness of approximation attained with various numbers of sine wave components.[22] Two significant conclusions may be drawn:

1. In analytical work, if a problem for a multifrequency input can be solved and the limit be evaluated as the number of components approaches infinity in such a way that the desired power spectrum is also approached, the solution for a corresponding noise input is obtained. Conversely a noise solution may be applied to a multifrequency transmission system such as used in carrier telephony or telegraphy.
2. In experimental testing, noise inputs may be simulated by multifrequency sine waves and conversely loading of multifrequency transmission systems, such as used in carrier telephony or telegraphy, may be simulated by appropriate noise bands. In measuring distortion in multichannel carrier a powerful technique is to load up the transmission with a wide band of noise from which the frequency range occupied by one channel is removed. The energy received in that channel is a measure of the nonlinear distortion spectrum caused by the multichannel transmission system.[23]

Approximation of Gaussian noise by superposing sine waves illustrates a general principle regarding the distinction between noise and signals which is like that used by a gardener to distinguish between weeds and useful plants; namely, noise may be merely a signal out of place. Man-made electric noises fit this description in so far as they arise from processes which are highly desirable in the originating circuit, but which are extraneous in the circuit under measurement. Speech signals for example are of sufficient value to justify design of highly precise electric circuits for their transmission over long distances, but if the speech wave induces a current in an electric circuit other than the one to which it is assigned, the induced component is called "crosstalk" and treated as a special kind of noise.

The distributions resulting from combining various numbers of independent speech waves are shown in Fig. 3. It is seen that while one talker has a highly non-Gaussian distribution, 64 talkers superimpose into close approximation to Gaussian noise.[24] This is in agreement with telephonic experience. Simultaneous crosstalk from a very few talkers gives an effect like eavesdropping on several conversations at once, but if there are many sources of crosstalk, such as is the case in a cable carrying hundreds of voice channels, the resultant is noiselike. The latter phenomenon has earned the descriptive name of "babble." In multichannel radio or carrier systems the "crosstalk" consists not only of superimposed intelligible speech but of crossmodulation components which are nonlinear, nonintelligible combinations of signals from different channels.[23]

In addition to the man-made noises arising from interference by signals in other channels, such utilitarian sources as "power hum" and "impulse noise" must also be dealt with. The former is associated with the use of alternating current for power supply and consists of harmonics of 60 cycles per second. The latter commonly arises from switching operations and is characterized by its wide spectrum and the fact that the amplitude as well as the power is proportional to the bandwidth accepted. That is, as the name indicates, "impulse noise" consists of sharp nonoverlapping pulses in which phase relations of the components determine the wave form.

A particular kind of noise which has become interesting in recent years is quantizing noise suffered in converting signals from analogue to digital form. This represents a rather large scale attempt to imitate nature by building signals out of current or voltage quanta instead of allowing them to range over all amplitudes. The advantage attained is that errors caused by extraneous noise may then be recognized if they do not exceed half a quantum. This enables regenerative repeaters to remove errors before they accumulate to half a quantum and thereby to repeat the signal an indefinite number of times without accumulating any error. Thus it is guaranteed that the only errors which occur are those which are made deliberately when the signal

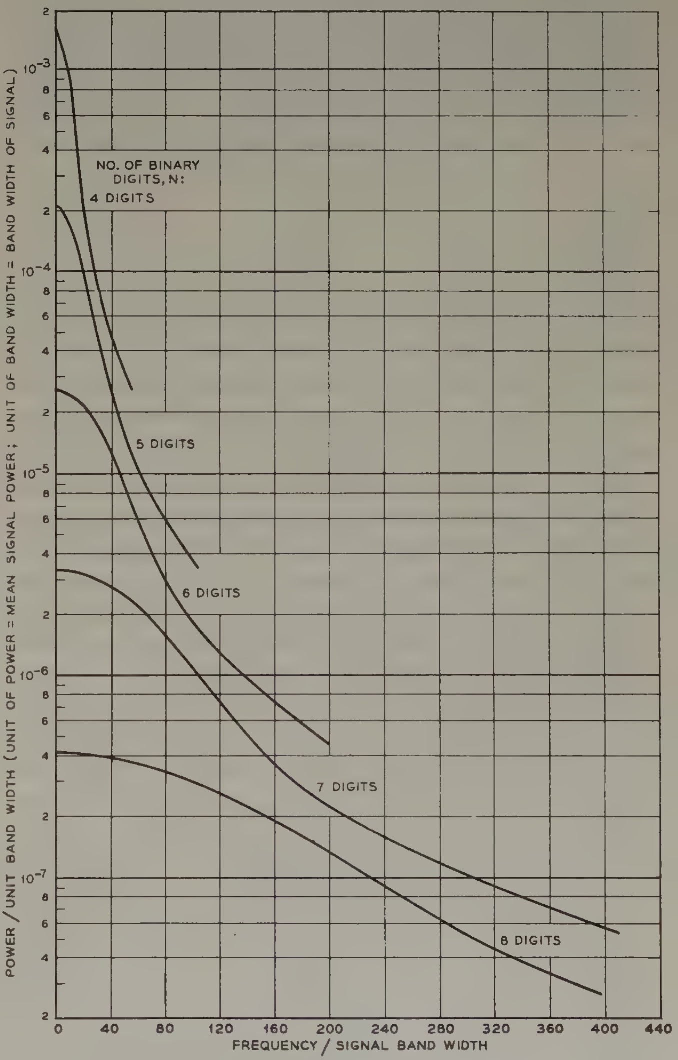

Fig. 4. Power spectrum of errors from quantizing white Gaussian noise with 2^N total steps

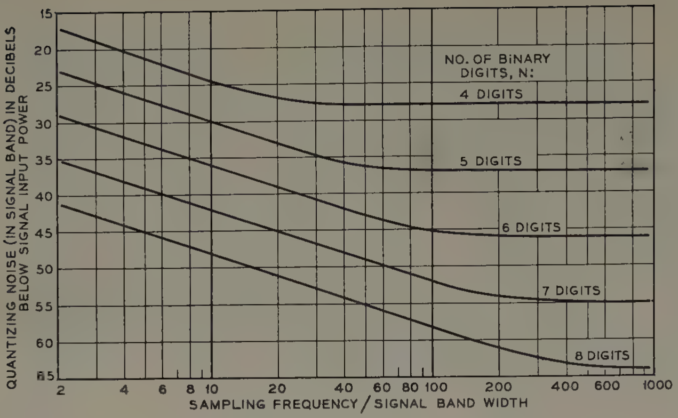

Fig. 5. **Noise power in signal band from quantizing white Gaussian noise samples with 2^N total steps**

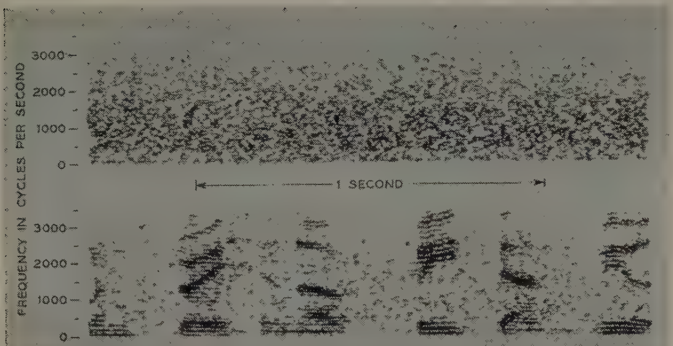

Fig. 6. **Spectrogram of quantizing errors and original speech signal for 128-step quantizer**

originally is quantized. To achieve the full benefits, the quantization of magnitudes must be accompanied by a discrete sampling process in time so that the regenerative repeater can maintain the proper time relations of the signal values. The quantizing errors consist of the differences between the original and quantized samples. If the samples are taken at twice the highest signal frequency and the quantization levels are close together, the successive values of error are nearly independent and a nearly flat spectrum results. Instead of being Gaussian, the distribution of error noise is rectangular between minus and plus half a quantum.

The calculated spectrum of quantization noise for various numbers of quantizing steps when the signal is white Gaussian noise is shown in Fig. 4.[25] Here the sampling in time has not been introduced and the output wave is assumed to change abruptly whenever the input wave passes from one quantizing interval into the adjacent one. The number of steps for the individual curves is 2^N, N being the number of binary digits required to specify the number. Fig. 5 shows the error spectrum for various sampling rates relative to the input signal bandwidth. An increase of one binary digit halves the rms error at the minimum sampling rate and thus yields a 6-db improvement in signal-to-noise ratio. Increase in the sampling rate from the minimum value gives in-phase addition of signal contributions and random-phase addition of errors until a sampling frequency is reached at which correlation between successive errors is appreciable. This explains the initial 3-db-per-octave improvement in signal-to-noise ratio as the sampling rate is increased above the minimum value and the eventual leveling off at high sampling rates. Finally Fig. 6 shows the audio spectrogram of the applied signal and the quantizing error falling in the signal band when the applied signal consists of speech plus a sufficient amount of thermal noise to span several quanta in the intervals between speech sounds.[26] It will be observed that the spectrum of the noise remains uniform as the input signal is varied—that is, that quantizing noise is virtually independent of the input signal provided that the latter does not stay within one quantum interval for an appreciable interval of time. For all practical purposes quantizing noise thus acts as a source of external noise related to the size of the quantum rather than to the size of the signal.

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Magnetic Amplifiers With Inductive D-C Load

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MEMBER AIEE

THE CIRCUIT is shown in Fig. 1. When the load becomes inductive, as expressed by finite ratios of $\omega L_L/R_L$, the control characteristic changes. This change is characterized by two features as shown in Fig. 2: 1. the control characteristic becomes shifted to the left; 2. instability, also called snap-action, occurs.

For instance, starting at *F*, and increasing the control voltage in a negative direction, the control characteristic for $\omega L_L/R_L = 0.105$ is traversed until point *A* is reached, where the stable region of the control characteristic terminates. By making the control voltage ever so slightly more negative, point *B* is reached and then operation continues along the so-called negative control branch *MBC*. It becomes apparent that an infinitely small change of control voltage is sufficient to produce the finite change of load current between *A* and *B*. While the control characteristic gives the illusion of an abrupt jump between *A* and *B*, one should not conclude that the change of load current from *A* to *B* occurs in zero time. Oscillograms indicate that it may take quite a few cycles before *B* is reached; these oscillograms show furthermore that in reality, the load and control currents follow an unstable branch of the control characteristic, beginning at *A*, and bending toward the minimum point *M*, as shown by the dashed curve. Somewhere near *M*, the operation transfers from the unstable characteristic *AM* to the stable, negative characteristic *MBC* and the currents follow to *B*.

Conversely, by increasing the control voltage in a positive direction, one moves from *C* along the negative characteristic which terminates at *M*. By increasing the control voltage beyond *M* by an infinitesimal positive amount, the load current increases from *M* to *D*, exhibiting another illusionary jump in the control characteristic.

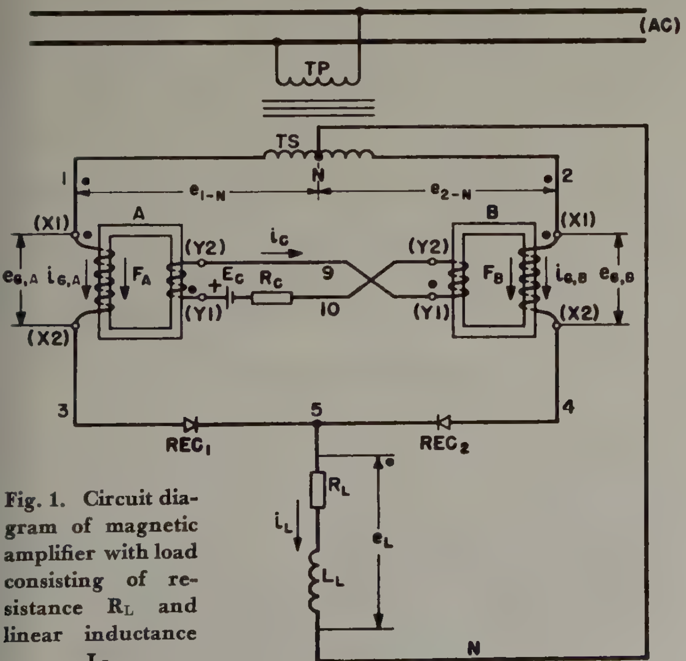

Fig. 1. Circuit diagram of magnetic amplifier with load consisting of resistance R_L and linear inductance L_L

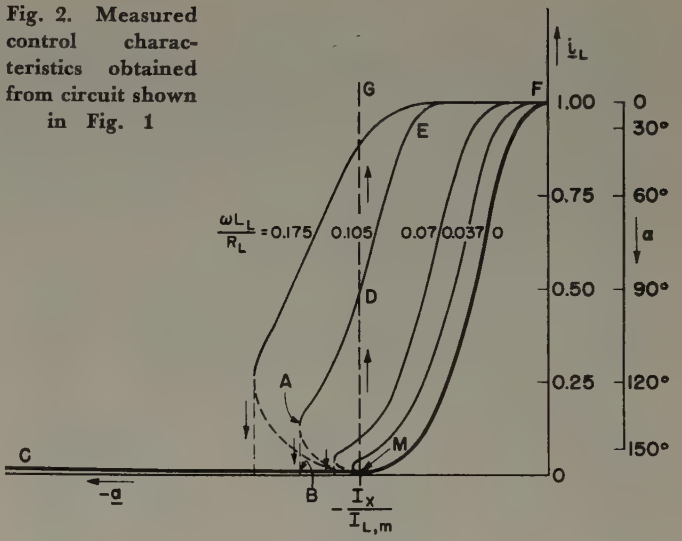

Fig. 2. Measured control characteristics obtained from circuit shown in Fig. 1

The total control current of the amplifier with inductive d-c load can be viewed as consisting of two components: one component which is the normal control current with purely resistive load, and an additional component, called the extra control current, which owes its existence entirely to the inductiveness of the load. The extra control current is generated by the transformation of load current into the control windings during the exciting intervals. It is always negative so that the control characteristic with inductive load is to the left of the control characteristic with purely resistive load.

For small values of $\omega L_L/R_L$ the extra control current remains practically constant for all load currents above a certain threshold and hence the control characteristic with inductive load is obtained from the case with resistive load by a left shift of constant magnitude. For load currents below the threshold, the left shift decreases and reaches zero at *M*. The curving back of the control characteristic shows the instability with inductive load.

Means to combat snap action is directed to prevent or render ineffective the transformation of load current into the control windings, or to prevent the amplifier from operating within the zone of instability. This transformation can be prevented by connecting a rectifier parallel to the load. The transformation can be rendered ineffective by increasing the resistance of the control circuit, or by placing an external inductance into the control circuit. The amplifier can be made to operate outside the zone of instability by raising a-c supply voltage.

Digest of paper 54-316, "Magnetic Amplifiers With Inductive D-C Load," recommended by the AIEE Committee on Magnetic Amplifiers and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Summer and Pacific General Meeting, Los Angeles, Calif., June 21–25, 1954. Scheduled for publication in AIEE *Communication and Electronics*, 1954.

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Loss of Field Protection for Synchronous Machines

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THE COMPLETE or partial loss of the d-c supply to a large synchronous machine can have serious consequences. This may be loss of stability in the power system with the resulting major loss of service or costly damage to the machine itself. On the other hand, it is desirable to maintain the machine on the line as long as possible supplying kilowatts to the system.

The type *HLF*, loss of excitation, relay has been designed with these objectives in view and it provides a higher order of protection than has been available before. See Fig. 1. It is a single-phase relay consisting of a directional element, an offset-impedance element, and an under-voltage element together with the necessary auxiliaries. The relay is connected and applied as shown in Fig. 2. The directional element closes its contacts for var flow into the machine. The offset-impedance element closes its contacts when, as a result of reduction in excitation, the impedance of the machine as viewed from its terminals is less than a normal value. Operation of both the offset-impedance and directional elements sounds an alarm. The additional operation of the under-voltage element trips the machine. Approximately 15 cycles time delay in energizing the trip coil is provided by the *X* relay to insure positive contact co-ordination under all possible operating conditions.

Momentary loss of excitation, for 2 or 3 minutes, is not hazardous to a steam turbine generator, and the excitation can be safely restored gradually even if the machine has lost synchronism. Up to the time of loss of synchronism after approximately 2 to 10 seconds the system is not particularly endangered. There is only a small change in kilowatt output but a large change in the var output into the leading power-factor zone. The system voltage is only reduced slightly. After loss of synchronism, the machine approaches the action of an induction generator with a cyclic variation in the real and reactive power flow and, to a lesser extent, system voltage.

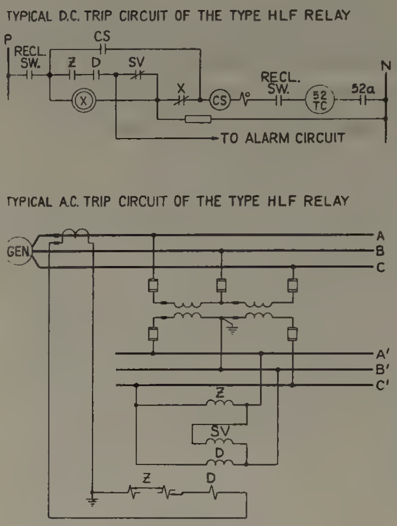
TYPICAL D.C. TRIP CIRCUIT OF THE TYPE HLF RELAY
P
CS
RECL. SW.
Z
D
SV
X
N
RECL. SW.
52 TC
52a
CS
TO ALARM CIRCUIT
TYPICAL A.C. TRIP CIRCUIT OF THE TYPE HLF RELAY
GEN
A
B
C
A'
B'
C'
Z
SV
D
Z
D

Fig. 2. Typical a-c and d-c schematic on the type HLF loss-of-field relay

The effect on the system of loss of excitation depends largely on whether the system can supply the var deficiency without a serious reduction in system voltage. Thus, system voltage is an excellent indicator of the ability of a system to maintain stability, and momentary loss of excitation might be very hazardous to the system if system voltage drops too low.

The *HLF* relay is designed to meet three situations. If a turbine generator loses excitation and dangerously low system voltage results, the machine is automatically tripped off the line. If the loss of excitation is not hazardous to the system, the relay warns the operator of the situation, allowing him to correct the cause of the trouble if possible, thus saving an unnecessary outage; or, if desired, the relay can be set to trip immediately under this condition. In addition, if the excitation of the machine becomes abnormally low for any reason and dangerous heating or loss of steady-state stability results, the relay warns the operator of this condition even though the excitation system is intact. In short, the relay analyzes the situation and either takes proper action itself or informs the operator.

Protection against loss of excitation is applicable to all classes of synchronous machines—turbine and water-wheel generators, synchronous motors, and condensers.

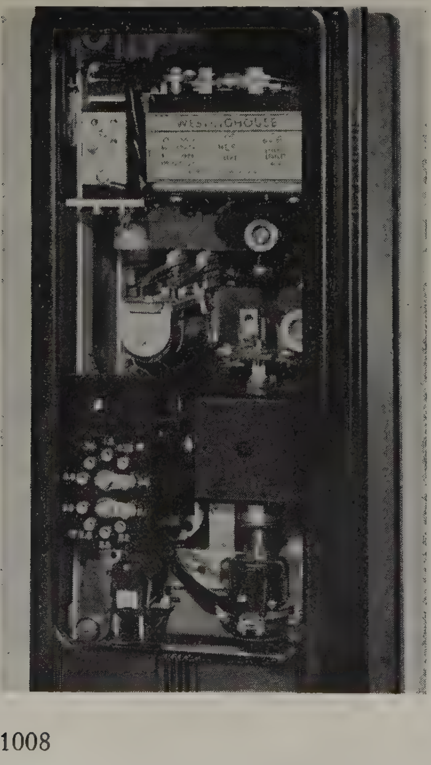

Fig. 1. HLF relay provides protection against loss of excitation to all classes of synchronous machines

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Digest of paper 54-115, "Loss of Field Protection for Synchronous Machines," recommended by the AIEE Committee on Relays and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 18–22, 1954. Published in AIEE *Power Apparatus and Systems*, August 1954, pp. 765–77.

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60-Cycle Induction Heating of Steel

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The need for faster heating methods in the steel industry can be met by low-frequency induction heating. So that full advantage of this type of heating can be taken, the heating cycle is discussed as well as the suitability of specific sizes of steel sections.

A NEW FIELD for the application of induction heating has developed. High-frequency heating of metal is already accepted as an indispensable tool of industry for surface heating and for through heating small pieces. The steel industry is now turning its attention to lower frequencies for heating large sections to forging temperatures, approximately 2200 F. The heating of steel for forming is a large part of steel manufacture. The methods used over the years have gone through an evolution. With the development of high-speed rolling and forming techniques, a need for faster heating methods has arisen. Low-frequency induction heating seems to provide a good answer to this need.

In the low-frequency range, commercially available frequencies, usually 60 cycles, are most popular, primarily because of the lower operating and first costs. In order that full advantage be taken of 60-cycle induction heating of steel, it is necessary to know what happens during the heating cycle. It is also necessary to understand why certain sizes of steel sections are better than others for the application of 60-cycle induction heating.

INDEX RATIO

OVER-ALL EFFICIENCY of heating a charge depends upon radiation losses from the charge and electrical efficiency. Electrical efficiency is dependent upon the ability of a charge to absorb energy. It is very critically affected by a quantity called index ratio, where for round sections

$$\Delta=\frac{{}^1/_2\text{ thickness of billet}}{\text{depth of penetration}} \qquad (1)$$

and for slabs

$$\Delta=\frac{\sqrt{2}\;{}^1/_2\text{ thickness of billet}}{\text{depth of penetration}} \qquad (2)$$

The index ratio, then, is a primary indication of whether or not a charge of given cross section can be heated with a given frequency.

DEPTH OF PENETRATION

FOR a billet of uniform permeability and resistivity, magnetic flux intensity, hence current density, decrease exponentially from the surface of the billet toward the center as shown in Fig. 1. This is true providing the index ratio is of the order of at least 6. The depth of penetration δ is defined as the depth at which the current density is $1/e$ times, or 36.8 per cent of its surface value. Heat generated is proportional to the square of the current. Hence, within the surface layer of depth δ, $[(1.0)^2 - (0.368)^2]$ or 86.5 per cent of the heat is generated. Providing the billet thickness is large compared to the depth of penetration

$$\delta=\frac{1}{2\pi}\sqrt{\frac{\rho 10^9}{2f\mu}} \qquad (3)$$

or

$$\delta=3{,}570\sqrt{\frac{\rho}{f\mu}}\text{ cm}$$

or

$$\delta=1{,}400\sqrt{\frac{\rho}{f\mu}}\text{ inches}$$

where

ρ = resistivity of material at temperature, ohm/cm
f = frequency, cps
μ = permeability of material at temperature

Fig. 2 shows that the resistivity of low-carbon steel increases steadily from about 20×10^{-6} ohm/cm at room temperature to about 120×10^{-6} ohm/cm at the Curie point. The Curie point, which occurs in low-carbon steel at about 1,400 F, is the point where steel undergoes a phase change and becomes nonmagnetic. From the Curie point to the melting temperature, resistivity increases very slightly.

The permeability of steel is difficult to fix numerically

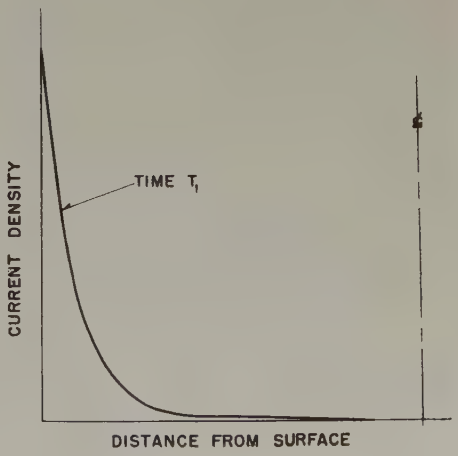

Fig. 1. Current distribution in a billet of uniform permeability

Full text of paper 54-465, "Induction Heating Steel with 60 Cycle," recommended by the AIEE Committee on Electric Heating and approved by the AIEE Committee on Technical Operations for presentation at the Middle Eastern District Meeting, Reading, Pa., October 5–7, 1954. Scheduled for publication in AIEE *Transactions*.

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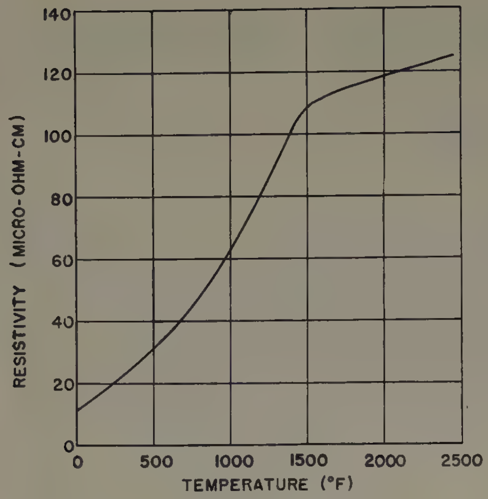

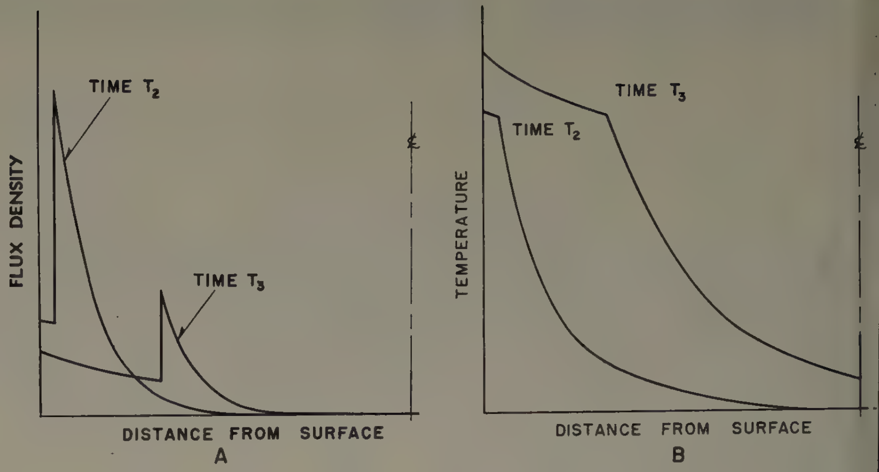

Fig. 2 (left). Resistivity versus temperature for 0.1 per cent carbon steel billet. **Fig. 3A (center).** Current distribution in a magnetic steel billet as the nonmagnetic region moves in from the surface. **Fig. 3B (right)** Temperature at times T2 and T3 in Fig. 3A

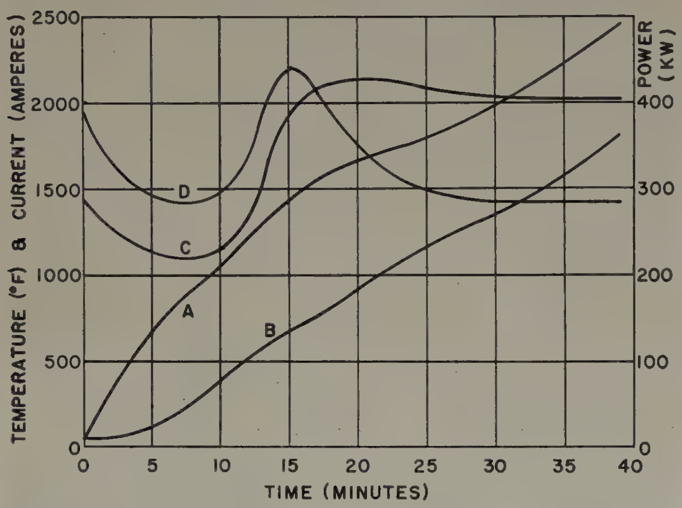

Fig. 4. Heating characteristics of a 13- × 13- × 32-inch 0.1 per cent carbon steel billet at constant voltage: *A—Surface temperature; B—Center temperature; C—Primary current; D—Power input to coil*

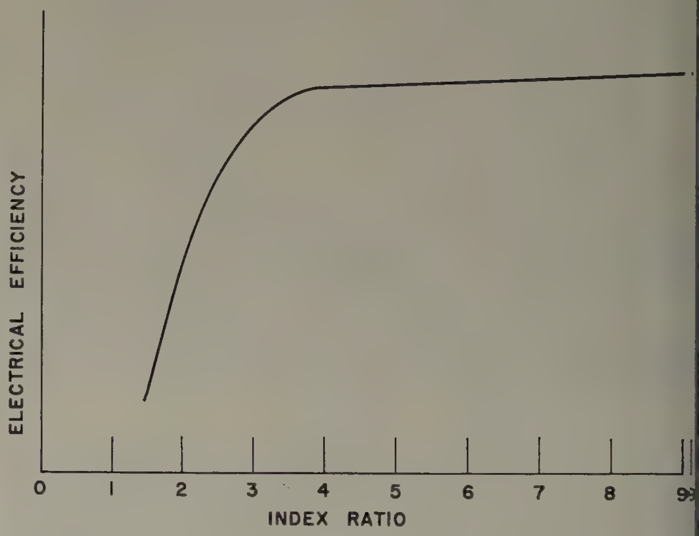

Fig. 5. Electrical efficiency versus index ratio for a solid cylindrical billet

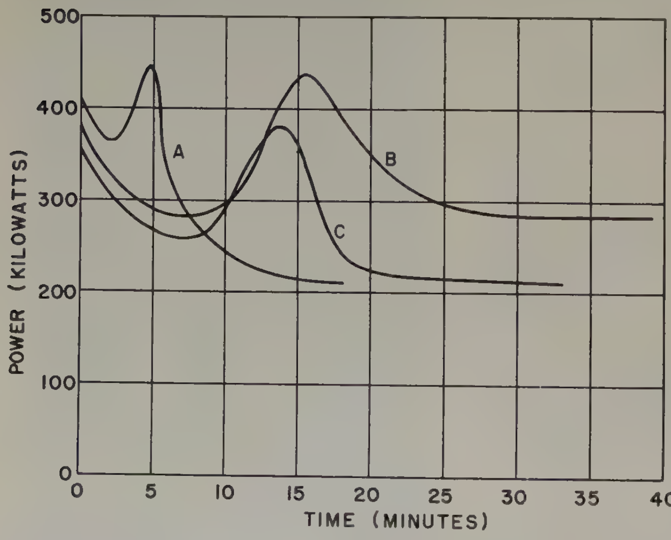

Fig. 6. Comparison of power curves for three cross sections of 0.1 per cent carbon steel: *A—8 × 8 inch; B—13 × 13 inch; C—6 × 18 inch*

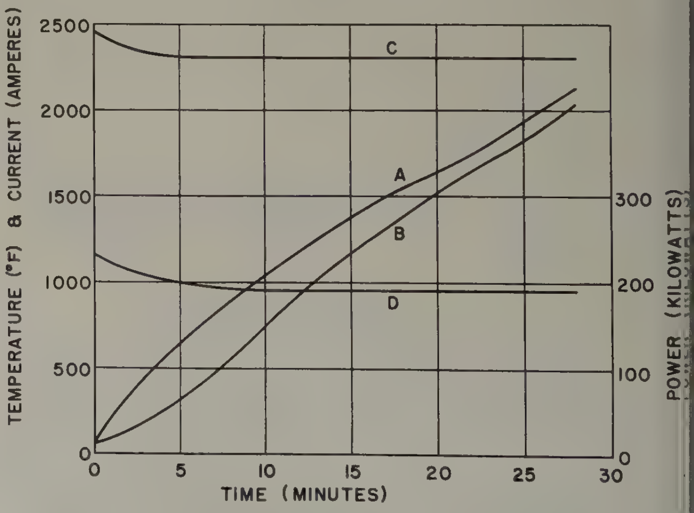

Fig. 8. Heating characteristics of a 7- × 8- × 32 inch nonmagnetic stainless steel billet: *A—Surface temperature; B—Center temperature; C—Primary current; D—Power input to coil*

because it changes with flux density. It also changes with temperature. At the Curie point the permeability may be assumed to drop to unity. For the purposes of this discussion, the permeability of low-carbon steel below Curie may be assumed to be 2,000.

Equation 3 may be used only when permeability is constant throughout the cross section of the billet. This occurs when the entire billet is above the Curie temperature. It also occurs when the maximum temperature in the billet is below Curie.

The resistivity, of course, also changes for different temperatures, and for accuracy may be put into the equation only when billet temperature is uniform. This is particularly important below Curie where resistivity changes rapidly with temperature.

For low-carbon steel at 70 F take

$\rho = 20 \times 10^{-6}$ ohm/cm
$f = 60$ cps
$\mu = 2{,}000$

Then

$\delta = 0.018$ inch

For low-carbon steel above Curie temperature take

$\rho = 120 \times 10^{-6}$ ohm/cm
$f = 60$ cps
$\mu = 1$

Then

$\delta = 2$ inches

The latter figure is only approximate for temperatures between Curie and forging because, as stated before, resistivity changes slightly in this range.

HEATING CYCLE

When power is first applied to a magnetic steel billet, resistivity and permeability being constant throughout the billet, current density assumes the exponential distribution shown at time T_1 in Fig. 1.

As the steel begins to heat, the resistance of the current path increases, see Fig. 2. The surface heats rapidly to the Curie point. As the surface becomes nonmagnetic, the point of maximum flux intensity and current density moves inward with the perimeter of the magnetic region. This has the effect of increasing the air gap and thereby increasing the inductive reactance in the primary circuit. When the surface of the steel becomes nonmagnetic, its current density and heating rate abruptly drop to lower values as shown by curves at times T_2 and T_3 of Fig. 3.

The billet continues to heat and the nonmagnetic region becomes deeper. Therefore, the cross-sectional area of the current path becomes greater and the resistance to current flow becomes less. Current increases causing the power to increase, see Fig. 4. This phase of behavior continues until the center of the billet becomes nonmagnetic. When this happens, there is no longer a magnetic core providing good flux linkage with the billet and the power abruptly decreases. Now all portions of the billet are above the Curie temperature and the depth of penetration formula given once again applies. This depth was calculated at 2 inches for the case of 60-cycle power.

INDEX RATIO AND EFFICIENCY

The index ratio, when it applies for a given billet, is determined by the frequency. Higher frequency results in higher index ratio. For a given frequency and a given temperature, billet thickness determines the index ratio. As can be seen from Fig. 5, if the index ratio of a round section becomes less than 2.5, the electrical efficiency falls off rapidly. This is also approximately true for slabs. The shapes of the curve of electrical efficiency versus index ratio for rounds and slabs differ slightly.

Fig. 7. Hot 8- × 8- × 32-inch carbon steel billet being removed from a test coil

The magnetic property of a steel billet causes the index ratio to be much higher than it is for the same billet in the nonmagnetic state. The magnetic property also causes good flux linkage with the billet. Therefore, the limiting situation occurs, if it occurs at all, when the steel billet is nonmagnetic.

The depth of penetration for low-carbon steel above Curie was calculated to be 2 inches using 60-cycle power. In order to insure an index ratio of 2.5, the diameter of a round billet, from equation 1, would have to be

$$\begin{aligned}\text{Diameter} &= 2\Delta\delta \text{ inches}\\ &= 2\,(2.5)\,2 \text{ inches}\\ &= 10 \text{ inches}\end{aligned}$$

For a slab, the thickness, from equation 2, would have to be

$$\text{Thickness} = \frac{2\Delta\delta}{\sqrt{2}} = \frac{2\,(2.5)\,2}{\sqrt{2}} = 7.07 \text{ inches}$$

The curves in Fig. 6, plotted from test data, show that 8- and 13-inch square billets (see Fig. 7) took about the same amount of power when they were magnetic and their index ratios were well above 2.5. When they became nonmagnetic, the power assumed by the 8-inch piece dropped well below that assumed by the 13-inch piece. The above Curie index ratio for an 8-inch round is 2.0, which puts the efficiency below the knee of the curve of Fig. 5. Data indicate that equation 1, given for rounds, yield approximate index ratios for squares.

From equation 2, the index ratio for a 6- by 18-inch slab is 2.1, see Fig. 6. As in the case of the 8- by 8-inch piece, whose index ratio is 2, the power taken by the slab drops to its lowest value when the billet becomes nonmagnetic. However, this drop is not nearly so great for the slab as for the 8- by 8-inch piece. This illustrates the fact that the knee of the electrical efficiency curve for slabs occurs at a lower value of index ratio than it does in the case of squares or rounds.

It is possible to heat a steel billet as small as 3 inches in diameter to forging temperature with 60-cycle power, although efficiency would be quite low. For pieces smaller than 3 inches, higher frequencies must be used above the Curie point.

NONMAGNETIC STEEL

A COMPARISON of the curves of Figs. 4 and 8 for magnetic and nonmagnetic steel shows that kilowatt and ampere curves for nonmagnetic steel do not peak as they do for magnetic steel. This, of course, is because the permeability does not change appreciably as the billet heats.

The temperature difference between the surface and the center is less for the nonmagnetic steel. This is because the billet takes a little longer to heat. Also, the heat is being generated deeper within the billet during the initial phases of the heating cycle. By watching the tops of the billets while they are heating, this difference in heating depth may be easily observed. A magnetic piece shows a well defined line between red and black. A nonmagnetic piece exhibits a fairly gradual color change from surface to center.

MAXIMUM SIZE

WHEN the index ratio is very large, the heating is being done very near the surface of the billet. The interior portion of the billet receives heat chiefly by thermal conduction. This is a relatively slow process. Time required for heating the center to temperature is great. The result is a reduction in over-all heating efficiency because of increased radiation losses from the surface of the billet.

Billets and ingots normally produced in steel mills are not considered very large in this sense. They do not usually exceed 36 inches in thickness, with index ratios of from 9 to 13. This is within the range of good heating efficiency for 60 cycles.

HYSTERESIS

IN a laminated transformer core, hysteresis power is large enough with respect to eddy current power to be a factor worthy of consideration. In the case of heating large solid masses of metal, with the high values of power normally used, eddy current power is so much greater that ordinarily hysteresis power may be ignored.

CONCLUSIONS

ROUND or square steel sections larger than 10 inches across and slabs larger than 7 inches thick may be heated with 60-cycle power with very good electrical efficiencies of the order of 70 or 80 per cent. Heating round or square steel sections between 3 and 10 inches across and slabs between 3 and 7 inches thick with 60-cycle power may be economically justifiable. As pieces become smaller than 10 and 7 inches, efficiencies become lower. Smaller pieces require higher frequencies above the Curie point.

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Laboratory to Test Fluorescent Lighting Ballasts

A new sound laboratory for testing and calibration of noise levels on ballasts for fluorescent lighting has been completed and put into use at the General Electric Company's Danville, Ill., plant.

The laboratory is part of the continuing progress being made toward "sound rating" of ballasts, so that users are able to specify the exact sound level requirements necessary for a particular application. This can vary from critical noise level in schools and hospitals to the higher noise levels possible in factory and industrial lighting applications.

Consisting basically of a room within a room, the new sound room incorporates some unusual features. The outer room is constructed of 8-inch concrete block walls filled with concrete, and an 8-inch poured concrete floor and ceiling. The inner room literally floats inside, resting on a series of isolators, which minimize any transmission of ground vibration. Poured concrete slabs, held together by concrete pilasters and reinforcing rods, make up the walls, ceiling, and floor, and virtually eliminate all outside sound.

An Expanded and Modernized Industrial Power System

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The original electric power system is described briefly together with the modifications and extensions and a supplementary higher voltage system. The discussion of the new system includes design considerations peculiar to plants requiring a high continuity of service.

IN RECENT years nearly all established industrial plants have experienced considerable growth. As a result of the change, the industrial electric power systems thus have been called upon to accommodate rapidly expanding production facilities. Kodak Park is no exception. This large industrial plant of the Eastman Kodak Company in Rochester, New York, employs approximately 20,000 people. The products of this plant are mainly photographic film, paper, and chemicals. The area occupied by the plant is approximately 545 acres, having somewhat irregular boundaries and extending approximately $2^3/_4$ miles in length. Its power division furnishes electric, steam, refrigeration, water, gas, compressed air, and distilled water services to the entire plant.

Source of Electric Power. The present weekday a-c electric power requirement for the plant is approximately 45,000 kva. Of the total electric power supplied to the plant, approximately 95 per cent is generated in the company's steam plant, and the remaining 5 per cent is purchased from the local utility company. The utility tie is operated closed so that the entire company generation system is operated in parallel with the utility generation.

Load Characteristics. A large portion of the plant manufacturing operation is on a continuous basis; that is 24 hours per day, 7 days per week, and, in some cases including holidays. The minimum load is experienced over weekends, and is approximately 50 per cent of the maximum peak load during weekdays. The night load is approximately 75 per cent of the daytime peak. The entire plant monthly load factor averages approximately 77 per cent; the yearly load factor approximately 70 per cent.

D-C Generation. The original plant electric generation was at 240 volts direct current. The present d-c load is 2,000 kw, but inasmuch as this load is of minor importance, it will not be discussed further here.

A-C Generation. The original plant a-c generation and distribution was at 2,300 volts, 60-cycle, 3-phase. Following World War II this was supplemented by generation and distribution at 13,800 volts, 60-cycle, 3-phase. These systems operate in parallel with each other and with the local utility.

The 2,300-Volt System. The 2,300-volt 60-cycle system had its beginning in 1920, see Fig. 1, and was expanded and modified at various times as the plant's electric requirements grew. The early expansions were simply increases in generation and utility tie until switchgear fault capabilities were exceeded, and then a synchronizing bus with reactors was added to reduce fault duty. Just prior to World War II the 2,300-volt generation totalled 24,375 kva in addition to a 6,000-kva transformer tie with the utility company's 11,500-volt system.

2,300-VOLT EQUIPMENT

It may be of interest to briefly describe the equipment associated with this 2,300-volt system at the time of World War II.

Generation. Conventional industrial-type turbogenerators were in use with electric ratings from 1,875 to 6,250 kva. The turbines were designed to operate as steam pressure reducing stations, some taking steam at 260 pounds per square inch gauge, others at 800, extracting and exhausting steam at various pressures to supply plant process and heating load. All units were direct-connected 3,600 rpm machines with direct-connected exciters.

Utility Tie. There were two 11,500-volt circuits from the utility company connected for the exclusive use of Kodak Park, and stepped down to 2,300 volts through a single 6,000-kva oil-filled water-cooled transformer.

Switchgear. The main high-voltage switchgear units were mostly the conventional oil circuit breaker, draw-out cubicle type of 1930 vintage, with a few of later metal-clad type. During 1938, as previously stated, the synchronizing bus with reactors was added to limit fault duty on the switchgear to a reasonable value. Fault duty, however, was still relatively severe, and switchgear fault capability was rather indefinite. Thus it was impossible to be certain that switchgear interrupting and momentary current capabilities were adequate. Some consolation was afforded by the fact that the system was grounded through a zigzag transformer plus a resistor with practically all distribution circuits in paper-insulated lead-covered cables. The result is that practically all faults are ground faults, and therefore limited and easily interrupted.

Distribution. The distribution system used practically all paper-insulated lead-covered cables in underground ducts. Early ducts were tile encased in concrete, and later ducts were either fiber or asbestos with cement conduits and concrete separation and envelope.

Full text of a conference paper presented at the North Eastern District Meeting, Schenectady, N. Y. May 5–7, 1954 and recommended for publication by the AIEE Committee on Industrial Power Systems.

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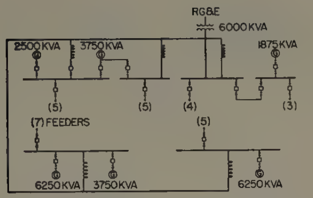


Fig. 1. Single-line diagram of 2,300-volt system previous to installation of 13,800-volt system

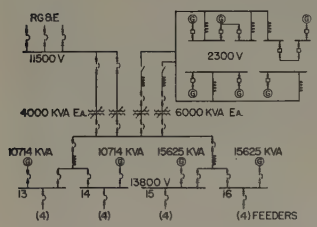


Fig. 2. Single-line diagram of entire high-voltage system, including ties between the 2,300-volt and the 13,800-volt systems and the utility tie

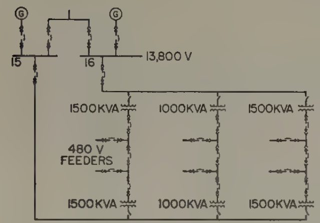


Fig. 3. Single-line diagram of typical high-voltage distribution feeders to load center unit substations

Substations. The early substations utilized oil-filled distribution or power transformers; the later substations made use of askarel-filled transformers. Busses and high-voltage switching equipment in most cases were the open type, fabricated and assembled in the field. High-voltage busses were hand taped with insulation and asbestos for fire protection. The circuit breakers, for protection of low-voltage secondary circuits, were in most cases the open type, field mounted on steel frames, and connected to open bare copper busses.

Some of the more important loads were provided with two 2,300-volt feeder circuits with associated manual switching to improve reliability and to make possible general maintenance without the necessity for interruption of load.

13,800-VOLT SYSTEM

At the end of World War II it was evident that Kodak Park was entering a period of relatively large plant expansion requiring a major addition to the electric power system. The existing 2,300-volt load had grown to approximately 25,000 kva which, with its associated generation, closely approached maximum capability of existing and available switchgear equipment, allowing for a reasonable voltage regulation under varying load and generation.

The electrical expansion engineering study considered five major requirements:

1. Continuity of service.
2. Cost.
3. Standard equipment.
4. Safety.
5. Indefinite expansion.

The nature of Kodak Park's continuous-process production, as mentioned previously, requires day and night service, and in some cases includes holidays. There are feeders on which a failure of only a few seconds may result in heavy financial loss. Thus, it was felt that the system should be arranged so ordinary equipment failure or maintenance operations would not result in production department service shutdown. It was concluded that the minimum system to meet these needs would be one having a dual high-voltage and transformer supply with automatic transfer on the unit substation low-voltage busses, thus permitting failure or maintenance shutdown on one high-voltage cable or its associated transformer without load shutdown.

As the cost of the proposed new system was high, it was considered advisable not to abandon any of the existing system, but rather to make full use of existing equipment by interconnecting it with the proposed new system and operating the whole as an integral system.

It was felt the proposed system should make maximum use of standard equipment in order to obtain the best manufacturers' designs at the lowest cost. It was also believed that standard equipment would speed deliveries for emergency maintenance and future expansion. An effort was made to select a suitable voltage and switchgear equipment that appeared to be developing as long time standards. In 1944 the status of manufacturers standardization was at such an early stage that selection of a standard voltage involved an element of uncertainty. A suitable voltage for handling the predicted 70,000 to 100,000 kva of additional generation economically and safely seemed to be in the 15-kv range. The final selection of 13,800 volts appears at present to have been a satisfactory choice, both from a standard and handling standpoint.

As the company places a high priority on personnel safety, it was felt that the equipment should be enclosed and controlled in such a manner that operation and maintenance could be accomplished without exposing personnel to energized equipment. Dual high-voltage supply to all loads and metal-clad equipment in large measure provides this degree of safety and convenience. Dual tie lines between the interconnected systems also add to safety and convenience.

This plant, similar to many others, is faced with indefinite expansion probabilities. Evidence indicates the future electric power requirements may greatly exceed the existing capacity. However, the nature of production is such that power requirements do not necessarily vary directly with plant output, but are heavily influenced by changes in production methods and the type of output. Thus, it is inadvisable to estimate power expansion based solely on probable plant production growth. The electric generation is also associated with a complicated plant steam generation system required to supply plant steam loads at various pressures and in varying amounts, using the turbogenerators as steam pressure reducing stations. The efficiency of the steam plant depends to a large extent on proper steam balance. Thus, the location, characteristics, size, and operation of turbogenerators is determined by a compromise between electric and steam requirements. Therefore, the electric system must be sufficiently flexible to allow for a somewhat indefinite amount and location of electrical expansion as well as a variation in size and operation of generation units as dictated by steam requirements. In 1944 it appeared the probable range of generator sizes would be between 10,000 and 15,000 kva. Present-day evidence indicates some of the future generators may be larger than 15,000 kva.

Generation and Busses. The 13,800-volt bus arrangement chosen as the initial portion of the new system will accommodate 4 generators of approximately 15,000 kva maximum size each, together with suitable interconnection through a tie to the existing 2,300-volt system, and to an enlarged interconnection with the local utility. See Fig. 2.

The initial installation made in 1948 included all switchgear, busses, interconnections, etc. shown, with the exception of busses no. 15 and no. 16 which have been added only recently. Generating units no. 13 and no. 14 were also installed in 1948. Generating unit no. 15 will go in service in 1954, and it is expected that unit no. 16 will be installed about 1956.

Units no. 13 and no. 14 have a nominal rating of 7,500 kw each, but are equipped with oversize generators of 10,714 kva, which gives them a capability of 9,100 kw at our plant power factor of 85 per cent. The driving turbines, being of the industrial-extraction type, have a maximum capability of 125 per cent or 9,375 kw. This combination of turbine and generator allows the development of the full kw capability of the turbines and, at the same time, permits the generators to supply to the system practically their full share of reactive kva necessary requirements. It may be of interest to note that all the company's a-c turbogenerators have, in a similar way, been given a capability rating which corresponds to the plant power factor of 85 per cent. Industrial turbines in general have a capability of 125 per cent of nameplate, which permits the development of these ratings.

Generators have surge suppressors installed at generator terminals and have their neutrals grounded through resistors. It is proposed to limit ground current on the systems to approximately 1,600 amperes, which is slightly above the largest current transformer rating connected to operate ground relaying. The limited ground current reduces ground fault damage.

Interconnection Facilities. Both the interconnections with the old 2,300-volt system and with the local utility are provided with askarel transformers having load ratio control. This feature is under the manual control of the switchboard operator, and allows a very close regulation of bus voltages under varying conditions of interchange between systems. Generators are also equipped with automatic voltage regulators.

Switchgear. All 13,800-volt switchgear, and the 11,500-volt switchgear associated with purchased power is the vertical lift, metal-clad type, with air circuit breakers of 15-kv, 1,200-ampere rating, and 500,000 kva interrupting duty.

Future Expansion. Two additional 13,800-volt generator busses, each with a 15,625-kva generator, can be added to the present system through the 13,800-volt tie or synchronizing bus without exceeding momentary current or interrupting rating of the existing equipment. System expansions beyond that point are feasible, but outside the scope of this article.

Distribution. Each generator bus has switchgear controlling four outgoing 13,800-volt feeder circuits, see Fig. 3. The uniform scheme of distribution used on the 13,800-volt system is to run the feeder circuits in pairs to the various sections of the plant. The two circuits of a given pair in all cases are supplied from two different generator busses. The system uses 3-conductor 350-MCM paper-insulated lead-covered cables which are carried in underground ducts. The maximum loading for each pair of cables is approximately 6,500 kva, and either cable will carry the entire load should the other cable fail or be shut down for maintenance. The more recent cables are paper insulated with lead sheath and a neoprene jacket to prevent electrolytic corrosion. At points near centers of load, unit substations are installed, taking their supply from the nearest pair of 13,800-volt distribution circuits. In most cases these unit substations are factory co-ordinated and assembled double-ended type having secondary selective arrangement, see Fig. 4. This arrangement involves the use of main secondary low-voltage circuit breakers and a tie circuit breaker for connecting the two sections of low-voltage bus. Normally the tie breaker is open and each half of the substation operates as a unit with its high-voltage supply, transformation to utilization low voltage, and circuit breaker protection for low-voltage feeder circuits. Whenever required, the entire low-voltage load can be connected to one end of the substation by closing the tie breaker and opening the appropriate main secondary breaker. This, of course, assumes sufficient capacity on the end remaining in use, otherwise the low-voltage load must be disconnected until a value is reached which can be tolerated. In nearly all substation installations, provision is made to automatically effect this transfer of load when voltage on one end falls below approximately 70 per cent of normal. Manual transfer can also be made without interruption of any load.

Substation transformers are either standard dry type, sealed dry type, or askarel filled. The sealed dry-type and askarel-filled transformers are installed in areas serving critical loads. The standard dry type are installed in all other areas. It has been found that substations with a 1,500 kva, 13,800- to 480-volt transformer on each end are about the maximum economical size when feeder breakers are in the 600-ampere frame size. Larger units require either special high-impedance transformers or larger and much more expensive low-voltage feeder breakers. The main low-voltage circuit breakers have overcurrent relays instead of direct attachment overloads so they may be easily tested and set to co-ordinate with high-voltage feeder cable relays. The substation employing standard dry-type transformers are usually planned such that maximum load will be approximately 3/4 the total transformer rating. That is, a substation with two 1,500-kva dry-type transformers would be loaded to approximately 2,250 kva. When the entire load is transferred to one end

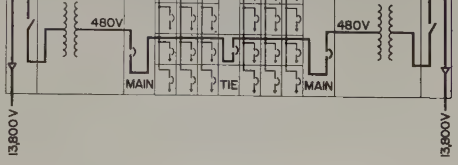


Fig. 4. Single-line diagram of typical load center unit substation

for maintenance or emergency reasons, the remaining transformer is loaded to approximately 150 per cent of its rating. These periods of operation on one end may extend from a few hours to two or three days. To assist in handling this overload, transformers are purchased with attached fans giving a supplementary name-plate rating of 33 per cent above the base rating. The main breakers are sized such that their rating will not be exceeded. As previously stated, the sealed dry-type and askarel-filled transformers to date have been installed in areas where they supply the most critical loads. It is felt these transformers will not withstand overload to the extent that standard dry-type transformers will; thus these substations are loaded to the rating of one transformer only so they are capable of carrying the entire load on one end continuously.

There are, at the present time, 25 of these double-ended units in service on the system, and additional units are frequently being added as required.

This scheme of distribution has proved to be very satisfactory. It allows an orderly maintenance program to be carried on without the necessity for interruptions to important loads. In a similar way, it allows unit substations to be added and connected to existing pairs of 13,800-volt circuits already feeding other substations, without the necessity for load interruptions. It will also be seen that a generator bus can be taken out of service without loss of essential load. Maintenance operations are usually carried on during periods of reduced load which allows the necessary transfers with the least amount of transformer overload.

It is proposed to transfer production department loads from the 2,300-volt system to the 13,800-volt system and reserve the 2,300-volt capacity for large motor drives in the Power Division. These drives would be in refrigeration, water, and steam boiler auxiliary service. There are approximately 10,000 hp of such motors now on the 2,300-volt bus, and it is expected the full capacity will eventually be utilized by such drives.

Present Loads. The present load is 20,000 kva on the 2,300-volt system and 25,000 kva on the 13,800-volt system.

CONCLUSIONS

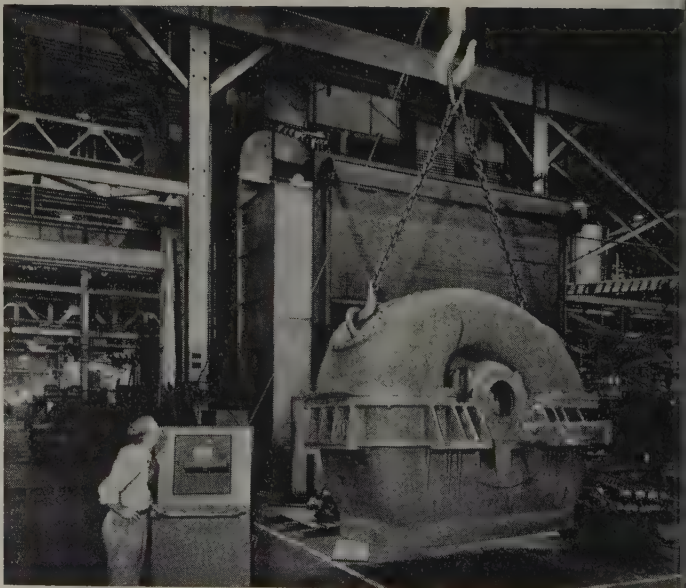
1. American industry can be expected to continue outgrowing its existing electric systems due to expanded use of electric energy per man hour and general plant growth.
2. The maximum load that can conveniently and economically be handled on a 2,300-volt system, unless generating units are limited to a small size, and fairly high voltage regulation can be tolerated, is about 25,000 kva.
3. A suitable voltage for a large industrial system, from the standpoint of cost, standard equipment, and safety in handling, appears to be 13,800 volts.
4. The dual high-voltage supply system associated with the double-ended power center unit substation appears to be a satisfactory solution to: (a) continuity of service, (b) safe, convenient maintenance, and (c) safe and convenient expansion.
5. The bulk of the load at Kodak Park is not of the high-priority type. However, experience has shown that nearly all departments do frequently add small increments of load of a continuous and essential nature. These small items of load make it increasingly difficult and costly to interrupt the electric service. It has been concluded that this tendency is sufficiently important to warrant supplying all the production departments with dual service. It is believed that modern production requirements may make a similar quality of service advisable in many other plants.
6. The system discussed satisfactorily serves the existing requirements and appears suitable for future needs. Therefore, it is expected that future expansion will be made using similar arrangements and equipment.

Electric Crane Scale Has 50-Ton Capacity

Costs of weighing the huge parts, assemblies, and housings of turbines, generators, and propulsion gears before shipment from General Electric Company's River Plant in West Lynn, Mass., were reduced 10 to 12 per cent following installation of a Baldwin-Lima-Hamilton Corporation's electric crane scale of 50-ton capacity. Savings are reported for an average of 8 weighings per day.

The crane scale can be used on any of nearly 100 cranes. One of the several conveniences provided by electrical weighing is the fact that tare weight, which varies considerably from one weighing to the next, can be zeroed out by turning a knob on the Baldwin load indicator before picking up the load. The indicator then reads directly in net pounds of load, not including chains or other supporting accessories.

Weighing accuracy is within 0.2 per cent for loads above 15 tons. The scale is graduated in 200-pound divisions and can be read to 50 pounds.



Measurement of Quality Factors of Inductor Cores

CHANDLER STEWART

THE Engineer Reseach and Development Laboratories (ERDL), Fort Belvoir, Va., have encountered a requirement for information on the electrical properties of low-loss core materials at low flux densities. A review of the literature revealed descriptions of three methods inadequate for the purpose:

1. Relative measurements.
2. Methods involving subtraction of copper losses.
3. Wattmeter methods, such as the Epstein test.

By inspection of the exact equivalent circuit of a transformer, it can be seen that the mutual impedance is determined by the core loss and permeability, and is unaffected by copper losses and leakage reactances. Therefore, if two coils having negligible winding capacitance are put on the core sample, the core properties can be determined from mutual impedance measurements, regardless of the copper losses. Such measurements by the Campbell bridge are subject to an error magnification as encountered in copper loss subtraction. The Carey Foster bridge requires a bridge transformer or Wagner ground, and the sample must be shielded from the bridge arm inductor. The Felici bridge must be modified to provide a loss adjustment, and the variable inductor must be inconveniently located in a position far from metal or power-line harmonic fields.

In order to avoid these limitations, a new bridge circuit was developed. It was found convenient to employ ring samples about 1 to 2 inches in diameter. The biasing field is

$$H_{DC}=0.495I_{DC}(N_1-N_2)/l_1 \text{ oersteds}$$

The a-c field is

$$H_{AC}=0.495I_pN_1/l_1 \text{ oersteds}$$

The core properties are given by

$$\mu=l_1/\omega^2(C_1+C_2)\times 3.19\times 10^{-8}N_1N_2a$$

and

$$Q_m=\left(\frac{1}{C_1}+\frac{1}{C_2}\right)/\omega R_1\left(1-\frac{D_1}{\omega R_1C_2}\right)$$

where

a = core sample cross-sectional area, in square inches
C_1,C_2 = bridge arm capacitors, in farads
H_{AC} = a-c field level, in oersteds
H_{DC} = core sample biasing field, in oersteds
I_{DC} = biasing current, in amperes
I_P = primary alternating current, in amperes
l_1 = mean magnetic path length around core sample, in inches
N_1, N_2 = number of turns on primary winding and secondary winding respectively
Q_m = effective core sample quality factor
R_1 = bridge arm resistor, in ohms
μ = effective a-c permeability of core sample
ω = test frequency, in radians per second

This bridge offers the following advantages:

1. So long as the Q of C_1 is at least three times Q_m (easily achieved in high-quality mica or polystyrene capacitors) and C_1 is several times as large as C_2, there is negligible magnification of errors.
2. Accuracy is limited only by the calibrations of resistors and capacitors, which are generally superior to those of inductors, especially if the latter employ iron cores.
3. Since no bridge transformer or inductors are used, there is no stray magnetic induction problem or noise pickup problem. As in any bridge, however, tests at extremely low levels may dictate the use of a step-up input transformer in the null detector to bring the null signal above noise in the first stage of the null detector.
4. The windings on the core sample may be very skimpy and easily put on by hand. One hundred turns would be typical for a 1,000-cycle test.
5. The core sample winding wire gauge may be selected purely for mechanical convenience, since the resistance of the wire is not involved.

As an approximate check on the operation of the bridge, the results were compared with data from other sources as listed.

1. Molybdenum permalloy dust core, $\mu = 125$, at 1,000 cycles:
   A. Computed from data by Legg and Given: $Q_M = 1{,}020$.
   B. Reported by Joe Mitch, Arnold Engineering Company, Marengo, Illinois: $Q_M = 600$ to 800.
   C. ERDL mutual inductance bridge: $Q_M = 730$.

2. General Radio variable inductor, type 107, at 1,000 cycles:
   A. Theoretical Q, neglecting eddy currents in metal parts and neighboring metal: $Q_M = \infty$.
   B. ERDL mutual inductance bridge: $Q_M = 800$. (It was noted that this Q depended upon the location of the inductor, and it is therefore assumed that the result would have been much higher if the measurement were made with the inductor located in a position further removed from surrounding metallic objects.)

REFERENCE

1. Compressed Powdered Molybdenum Permalloy for High-Quality Inductance Coils, V. E. Legg, F. J. Given. *AIEE Transactions*, vol. 59, 1940, pp. 865–72.

Digest of paper 54-291, "Measurement of the Quality Factor of Inductor Cores," recommended by the AIEE Committee on Instruments and Measurements and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Summer and Pacific General Meeting, Los Angeles, Calif., June 21–25, 1954. Scheduled for publication in AIEE *Communication and Electronics*, 1954.

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Properties of Plasticizers and Their Relation to Electrical Compounding

J. J. MORRIS W. J. CANAVAN

The properties of plasticizers and their influence on electrical compounds are reviewed in terms of plasticizer volatility and aging characteristics, plasticizer effects on resistivity of compounds, plasticizer influence on dry blending rates, and effects of clay on plasticized compounds.

THE past 10 years have marked a period of unusual development and tremendous growth in the use of plasticized polyvinyl chloride compounds for electrical insulation applications. For most of this period particular attention has been given to the properties of polyvinyl chloride resins, while a lesser degree of attention was focused on the properties of plasticizers and their influence on compounding techniques and the quality of electrical compounds. It is this latter consideration, the important properties of plasticizers used in the electrical insulating industry, that will be reviewed here. The main emphasis will be placed on properties which can be most easily used to determine the actual or potential usefulness of existing commercial plasticizers and which will serve as guide posts in the search for new plasticizers.

PLASTICIZER VOLATILITY AND AGING

PLASTICIZERS are compounded with polyvinyl chloride resins to facilitate processing and to impart flexibility. Because plasticizers are generally expected to function as permanent flexibilizing agents, it is necessary to be concerned with their permanence or volatility within the framework of their intended use. In the electrical insulation field, the volatility of plasticizers at the temperatures at which insulated wire will operate is most important.

Experience, developed through performing countless aging tests, has provided a clue whereby a reasonably accurate estimate can be made of the maximum operating temperature at which a plasticizer may be employed as the sole plasticizer. Fig. 1 relates the useful operating temperature based on service aging tests for Flexol* plasticizer *DOP*, Flexol plasticizer *TWS*, and tricresyl phosphate to the temperature at which these plasticizers have a vapor pressure of 0.05 micron of mercury. This graph shows that the temperature at which this vapor pressure is obtained correlates very well with the actual satisfactory service temperatures for these plasticizers as determined by Underwriters' Testing Laboratories oven aging tests. Table I shows the temperatures at which a number of plasticizers and plasticizer extenders develop a vapor pressure of 0.05 micron of mercury. However, it should not be concluded that the temperature listed for each plasticizer is an absolute limit on the service estimated for each plasticizer. Stabilization and filler content can be modifying factors.

Table I. Temperature at Which Plasticizers and Plasticizer Extenders Develop Vapor Pressure of 0.05 Micron of Mercury

Plasticizer	Temperature (C) at a Vapor Pressure of 0.05 Micron Hg
Paraplex *G-25*	Over 150
Flexol plasticizer *R2H*	Over 150
Paraplex *G-60*	Over 150
Halowax* plasticizer *4004*	Over 150
Flexol plasticizer *TWS*	93
Flexol plasticizer *8N8*	85
Monoplex *DOS*	84
Tricresyl phosphate	78
Plastolein *9058*	76
Flexol plasticizer *4GO*	73
Flexol plasticizer *2GB*	69
Flexol plasticizer *DOP*	68
Santicizer *141*	65
Dow *276 V-2*	65
Flexol plasticizer *CC-55*	59
Flexol plasticizer *A-26*	58
Flexol plasticizer *TOF*	57
Sovaloid *C*	35
Dibutyl phthalate	29
HB-40	25
Panaflex *BN-1*	25

It should be recognized that Table I deals with single plasticizer systems. When plasticizer blends containing two or more components are employed, there may be minor changes from predicted volatility characteristics.

These temperatures can serve as aids in readily cataloging plasticizers with regard to the probable maximum operating temperatures at which useful service can be expected, providing plasticizers are sufficiently compatible for use as the sole plasticizer. This rating method is based solely on the relative permanence of plasticizers and does not consider the importance of electrical properties, deformation resistance, or other properties which may be important to individual formulators.

PLASTICIZER EFFECTS ON RESISTIVITY OF COMPOUNDS

IT is important to choose plasticizers which will help impart good insulation resistance to compounds. In order to accomplish this it is necessary to recognize that plasticizers can affect insulation resistance in two ways:

1. Plasticizers may contribute ionic impurities to a compound.
2. The conducting power of a compound for a given

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* Registered trade-mark of Union Carbide and Carbon Corporation.

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concentration of ionic impurities may vary greatly, depending partly on plasticizer choice. Thus, it is possible for a compound prepared with plasticizer *A* to be higher in resistivity than a similar compound prepared with plasticizer *B*, even though both compounds contain the same percentage of ionic impurity.

Both factors are of considerable importance in selecting plasticizers for polyvinyl chloride insulating compounds. Special manufacturing techniques have been developed for removing ionic impurities from commercial plasticizers. Continuous improvements in this direction have resulted in the exceptionally good electrical properties found in such products as Flexol plasticizer *DOP*. Fig. 2 shows the effect of various specially prepared samples of Flexol plasticizer *DOP* on compound resistivity. *DOP* with varying liquid d-c resistivity was used to prepare the compounds investigated. The present d-c resistivity specification of 1 × 10^6 megohm-cm, minimum at 25 C placed on Flexol plasticizer *DOP* assures an electrical compounder of having a plasticizer with the lowest possible level of ionic impurities now attainable.

Some weight should be given to the second factor noted. In order to keep the effect of ionic impurities at a minimum, a plasticizer with inherently low conducting power should be chosen. The conducting power of a plasticizer in a compound may be evaluated by introducing a known concentration of an electrolyte into the compound and measuring the change in conductivity of the compound. Tetraethyl ammonium picrate has a large effect on the conductivity of plasticized compounds and is soluble in vinyl insulating compounds.

These general formulations were selected for trial:

	Parts by Weight	
	Formula I	Formula II
Bakelite vinyl resin *VYNW*	100	100
Plasticizer	30–70	30–70
Basic silicate of white lead no. 201	3	3
Stearic acid	1	1
Tetraethyl ammonium picrate		0.1

Plasticizer concentration is listed as variable because it was considered desirable to compare performance characteristics at Durometer *A* hardnesses of 80 and 85. Each compound was subjected to the same milling procedure, and pressed sheets were used for conductivity measurements which were determined at 50 C. The conductivity for each compound was determined by subtracting the conductivity of formula I from the conductivity of formula II. Table II shows the results obtained with certain commercial plasticizers at Durometer *A* hardnesses of 80 and 85.

These conductivities are independent of the ionic impurities imparted by the plasticizers and indicate the relative conducting power of plasticizers in compounds containing a known concentration of a particular electrolyte.

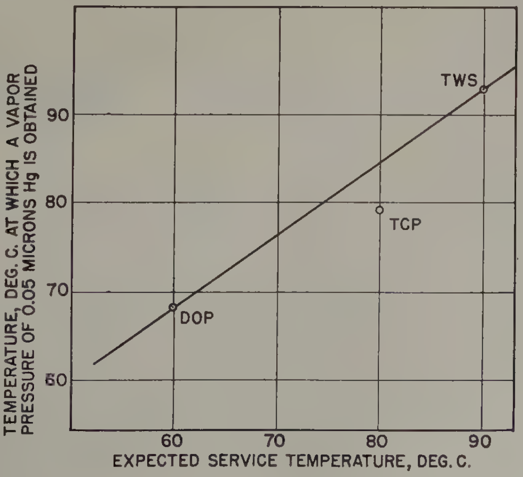
These data also indicate that the resistivity of a plasticized compound will vary inversely with the stiffness of a compound—the lower the plasticizer to resin ratio, the higher the resistivity which will be obtained. This is true with all plasticizers, but the rate of change varies. Table III illustrates the variation of compound resistivity with variations in plasticizer to resin ratios.

Table II

Plasticizer	Conductivity (mhos cm × 10_{H}^{-10}) 80 D	85 D
Flexol plasticizer *R2H*	6.8	5.5
Flexol plasticizer *DOP*	12	8.1
Flexol plasticizer *CC-55*	17	11
Tricresyl phosphate	17	11
Flexol plasticizer *TWS*	20	11
Paraplex *G-25*	19	12
Santicizer *141*	40	28
Flexol plasticizer *A-26*	72	42
Monoplex *DOS*	75	58
Flexol plasticizer *4GO*	90	78
Flexol plasticizer *TOF*	180	120

Table III. Plasticizer/Resin Ratio Versus DCR (megohm-cm)

Combination	Ratio	DCR at 15.5 C	DCR at 50.0 C
Flexol plasticizer *DOP*	32:68	6×10^8	2×10^7
	35:65	2×10^8	3×10^6
	38:62	9×10^7	8×10^5
Paraplex *G-25* and Halowax plasticizer 4003 (2:1 mixture)	38:62	1.8×10^8	1.1×10^6
	40:60	1.2×10^8	8.4×10^5
	42:58	6.2×10^7	5.9×10^5
Flexol plasticizer *R2H*	35:65	4.8×10^8	6.5×10^6
	38:62	4.3×10^8	4.4×10^6
	40:60	3.8×10^8	2.7×10^6



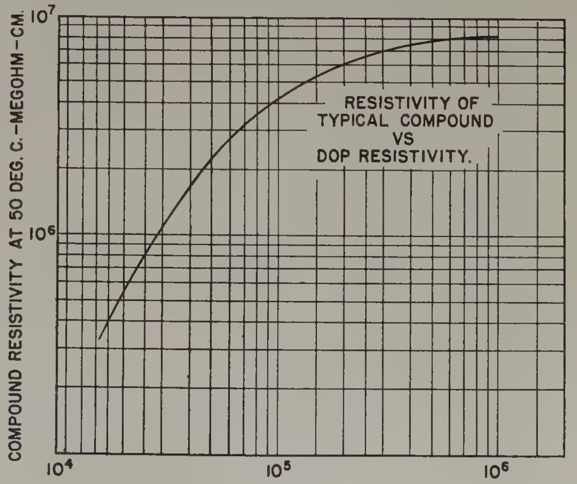


Fig. 1 (left). Underwriters' Laboratory 50-day aging test. **Fig. 2** (right). DOP resistivity at 25 C-megohm-cm

PLASTICIZER INFLUENCE ON DRY BLENDING RATES

The use of dry-blend extrusion techniques has aroused considerable interest. A mixture of resin, plasticizer, and all additional compounding ingredients is made and then heated to obtain complete absorption of plasticizer by the resin particles before it is fed directly to an extruder.

There are significant differences in the way plasticizers perform in dry preblending which are influenced by the chemical nature and concentration of the plasticizer. Fig. 3 shows data on dry-blending characteristics of commercial plasticizers obtained with the following test method:

"A 3,000-gram batch is weighed into a 12-quart Hobart blender bucket which is equipped with a steam jacket. Each batch consists only of resin and plasticizer which are introduced at room temperature. The mixture is blended cold for 3 minutes after which 15 pounds per square inch of steam are applied. Samples are taken every 2 minutes during the hot blending and tested for dryness. This is accomplished by sandwiching a sample between two pieces of absorbent paper and pressing under a 10-pound weight. After 2 minutes the paper is examined. When the paper is no longer wetted by the plasticizer, the blend is considered dry. Drying time is recorded as the time from the beginning of hot blending to the above end point."

This test results in longer blending cycles than can be obtained by other methods. It does, however, facilitate obtaining data to illustrate differences among plasticizers. From Fig. 3 it can be seen that the chemical nature of plasticizers and their concentrations influence major differences in blending times. These data indicate that widely different blending cycles may be required for various plasticizers and their combinations.

EFFECT OF CLAY ON PLASTICIZED COMPOUNDS

Additives such as calcined clay can be employed to make strikingly effective improvements in the electrical properties of plasticizers and of fabricated compounds. The addition of 3 per cent clay to an electrical insulation compound brings about a considerable improvement in electrical properties. The data summarized in Table IV illustrate this effect and emphasize once again that the rate of improvement varies from plasticizer to plasticizer.

Table IV

Plasticizer	D-c Resistivity Megohm-cm of Compound 3% Clay	 No Clay
Flexol plasticizer *DOP*		
15.5 C	8.0×10^8	8.0×10^7
50.0 C	1.7×10^7	7.7×10^5
Plastolein *9058*		
15.5 C	8.9×10^8	1.1×10^8
50.0 C	8.5×10^6	5.2×10^5
Tricresyl phosphate		
15.5 C	2.7×10^8	9.4×10^7
50.0 C	5.8×10^5	1.2×10^5
Flexol plasticizer *DOP* and Flexol plasticizer *TOF* (75:25 mixture)		
15.5 C	5.9×10^7	2.7×10^7
50.0 C	8.6×10^5	1.8×10^5
Flexol plasticizer *R2H*		
15.5 C	2.0×10^8	7.4×10^7
50.0 C	6.3×10^5	8.6×10^4
Paraplex *G-25*		
15.5 C	2.9×10^7	1.7×10^7
50.0 C	1.3×10^5	5.3×10^4

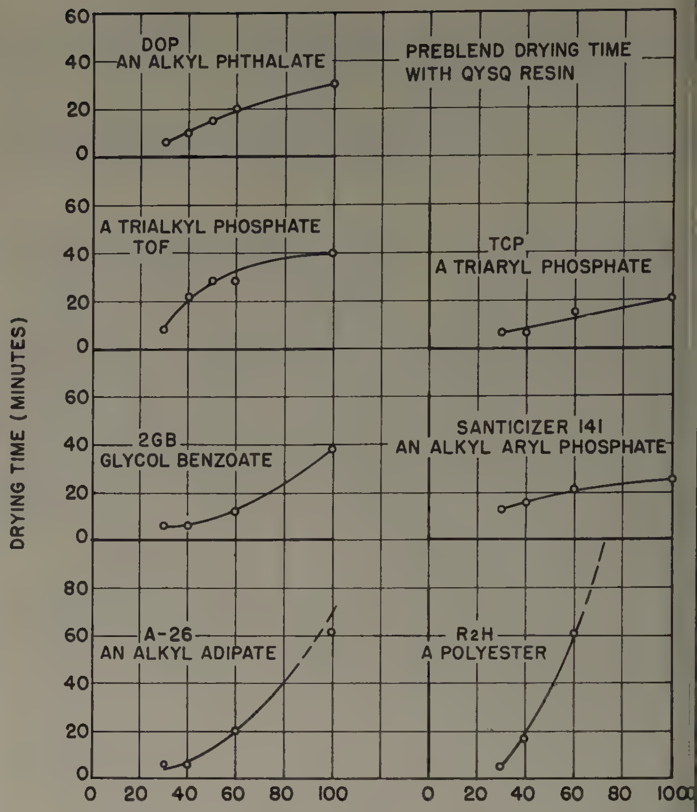


Fig. 3. Plasticizer concentration (phr)

From all the foregoing it may be seen that a number of factors must be considered in formulating vinyl compounds for insulation purposes. It is thought that this information will modify the tendency to believe that the electrical properties of vinyl resins fully establish the electrical properties of finished compounds. It is believed as much study should be devoted to considering the electrical properties of plasticizers used in electrical compounding as has been devoted to the study of resins. With consideration being given to the important properties of plasticizers and the test methods described in this summary, it is considered that improvements can be made in existing compounds based on the selection of the most suitable type plasticizer.

Appendix. Test Method WC-51, Method D

Apparatus: The apparatus shall consist of the following:

1. Leeds and Northrup No. *5602* Insulation Resistance Test Set which incorporates galvanometer shunts, calibrating resistance with shunting switch and reversing switches for the battery and for the external galvanometer. These items are wired, shielded, and provided with convenient terminals for connection to the external galvanometer, battery, and test specimen.
2. Leeds and Northrup No. *2500-f* galvanometer with wall bracket, lamp, and scale.
3. Eleven 45-volt batteries to provide a d-c potential of approximately 500 volts.
4. Water bath equipped with external means for heating and circulating the water, and thermoregulators to control the temperature to within ±0.5 C.
5. Thermometer, 0 to 100 C, (Weston metal type, model *226 L007* is suitable).
6. Clock or timer suitable for measuring a 60-second interval.
7. Micrometer, machinist's type, graduated to 0.001 inch, with anvil and spindle surfaces 0.25 inch in diameter.

Derivative Controlled Magnetic Amplifiers

A. D. SCHNITZLER
ASSOCIATE MEMBER

THE CIRCUIT shown in Fig. 1 is of a low-level fast-response magnetic amplifier, as developed for such low-level signals as are provided by thermocouples, strain gauges, etc. Rectifiers are not included in the input circuit, thus eliminating the restriction which they impose on the minimum signal voltage. Low drift, fast response, and high gain are obtained by the use of a combination of delayed positive voltage-current and negative current-voltage feedback. The delayed negative feedback current-voltage from a resistive load is added to the signal voltage in the control circuit of the first stage so that it amplifies the average increments of signal voltage per half cycle of power supply voltage. The positive voltage-current feedback is adjusted to just compensate for rectifier leakage and eddy current losses in the second stage. The function of the second stage is to amplify and sum the output voltage of the first stage.

In a 2-stage amplifier, drift is almost entirely due to variations in parameters of the first stage. The first stage functions as a derivative amplifier and the second stage as an integrator. Since the input stage operates upon the average increment of signal voltage per half cycle rather than the average signal voltage per half cycle, the effect of variations in the back resistance of the rectifiers and of core magnetizing current upon the output is diminished by the ratio of the increment to the entire signal voltage.

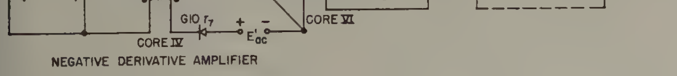


Fig. 1. Complete amplifier incorporating half-wave derivative amplifier

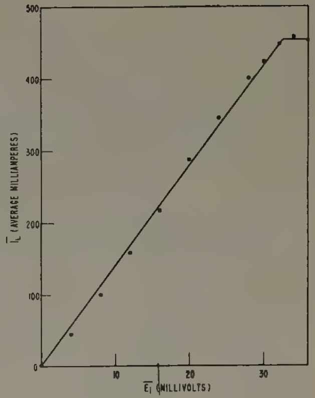


Fig. 2. Transfer characteristic

Referring to Fig. 1, cores I and II are parts of half-wave amplifiers connected in push-pull. I_1 and I_2 are current sources which bias the 2 amplifiers to zero output when the input is zero. $\bar{E}_i$ is the signal voltage and $\bar{E}_f$ is a negative feedback voltage proportional to the load current. The bar over the voltage symbol indicates the average voltage over a half cycle. With a resistive load, $\bar{E}_f$ is delayed 1 cycle by the amplifier. When conditions are such that $\bar{E}_i$ has been constant for 1 cycle or more, $\bar{E}_f=\bar{E}_i$ and the input to the half-wave amplifiers cores I and II is zero. However, if $\bar{E}_i$ is increasing, i.e., $\frac{d_i\bar{E}}{dt}>0$, $\bar{E}_i>\bar{E}_f$ since $\bar{E}_f$ is delayed in the amplifier. Then a voltage $\bar{E}_i-\bar{E}_f$ exists between terminals X_1 and X_4, such that X_1 is positive with respect to X_4. Voltage of this polarity is amplified by core I while core II is unaffected and its output remains zero. If $\bar{E}_i$ is decreasing, i.e., $\frac{d\bar{E}_i}{dt}<0$, $\bar{E}_i<\bar{E}_f$ and terminal X_1 is negative with respect to terminal X_4. In this case, the voltage $\bar{E}_i-\bar{E}_f=-\left|\bar{E}_f-\right|\bar{E}_i$ is amplified by core II while core I is unaffected and its output remains zero. Thus the output of core I is proportional to positive increments of signal voltage, while the output of core II is proportional to negative increments of signal voltage.

Cores III and IV are parts of a full-wave magnetic amplifier with sufficient positive feedback for it to function as an integrator. The positive feedback is provided by the N_4 windings on the cores. I_3 is a current source which provides bias by means of the N_1 windings. The N_2 windings are the control windings and the N_5 windings the load windings.

Since this circuit behaves as an integrator summing the increments of signal voltage amplified by cores I and II, the output current is a linear function of the input voltage. The transfer characteristic is shown in Fig. 2.

If the negative current-voltage feedback is delayed either by an inductive load or a low-pass filter, the first derivative of the signal voltage becomes a component of the load voltage. Thus the total time constant of a system incorporating this amplifier can be effectively reduced. This is especially valuable in such applications as driving a high-speed teletype relay, providing excitation to the field winding of a generator, providing excitation to the control winding of a 2-phase servo motor, or operating a magnetic clutch.

Digest of paper 54-375, "Derivative Controlled Magnetic Amplifiers," recommended by the AIEE Committee on Magnetic Amplifiers and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Fall General Meeting, Chicago, Ill., October 11–15, 1954. Scheduled for publication in AIEE *Communication and Electronics*, 1954.

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Radio Transmission on 230- and 400-Kv Lines

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IN SWEDEN the power lines for high voltages of 230 to 400 kv cause serious interference for radio listeners living in the vicinity of the power lines, particularly in the northern part of the country where the radio field strength of the broadcasting transmitters is low. The measures formerly adopted with a view to overcoming this interference, which mainly took the form of cabling the telephone and low-tension lines and moving the aerials further away, were found to be very costly and ineffectual in many instances. A new method has now been investigated, however, which has yielded successful results. It is based on the transmission of the radio program directly over the interfering line. The principle followed consists in the connection of a radio transmitter to the power line through a capacitor located in a suitable position in the line system (see Fig. 1). The transmitter output is so selected that the signal level for the radio program transmitted over the line exceeds the interference level from the power line by such an amount that the interference is no longer perceptible. Reception can take place in the usual manner by turning the receiver to the wavelength of the power-line transmitter, with no special adjusting.

Experience has shown that in order to obtain satisfactory radio reception, a ratio of at least 35 db is required between the signal voltage and interference voltage. Under the same external conditions the interference voltage will be constant along the line. If 1 mv is taken as the zero level the interference voltage will be −5 db in wet weather and −25 to −40 db in dry weather. In consequence of the line damping, however, the signal voltage will fall along the line in relation to its distance from the transmitter (see Fig. 1). When the magnitude of this line damping and the lowest signal interference ratio are known, the transmitter output required for a given range is

$$P=\frac{e^2}{Z}10^{\frac{l\times a}{10}};\ Z=\frac{Z_0}{n-1}$$

where P is the transmitter output, e is the signal voltage for the range limit, l is the distance to the transmitter in miles, a is the line damping in db per mile, Z is the impedance at the measuring point, Z_0 is the wave impedance of the line, and n is the number of line sections at the measuring point.

The necessary output at the range limit with the signal and interference-voltage levels stated will be $e^2/Z=1$ watt. The formula for the transmitter output can be simplified

$$P=10^{\frac{l\times a}{10}}$$

The line damping in db per mile is obtained from $a=20 \log e_1/e_2$, where e_1 is the voltage at a point on the line and e_2 is the voltage 1 mile further away from the transmitter. The line damping for 230 and 400 kv lines with frequencies between 150 and 200 kc will be of the order of magnitude 0.16–0.22 db per mile. At the aforementioned frequencies the wave impedance between one phase and earth is, practically speaking, purely resistive for lines with single conductors being of the order of magnitude of 400 ohms and nearly 300 ohms for duplex conductors.

Radio transmission over power lines has given excellent results and a number of installations are in service on 230- to 400-kv lines that once gave rise to interference.

Experiments undertaken subsequently have demonstrated that it is possible to connect a line radio transmitter to the line through a ground wire instead of through a capacitor. In this case it is necessary to insulate the ground wire for 1 or 2 miles from the transmitter. In order to enable the insulated ground wire to retain its protective effect it must be equipped with a spark gap to earth. It is also possible to take the power from the insulated ground wire for operating the line radio transmitter (see Fig. 2).

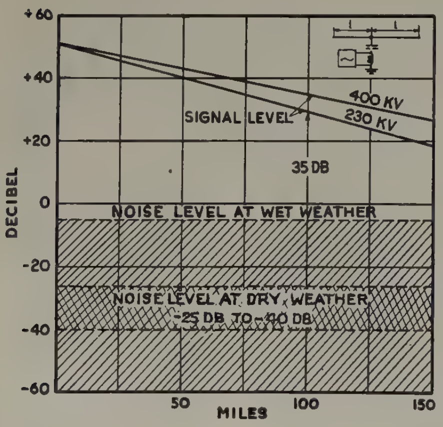

Fig. 1. Signal level as a function of line length and noise level in wet and dry weather. (P=2×125 w, f=182 kc, a=0.16 and 0.22 db per mile)

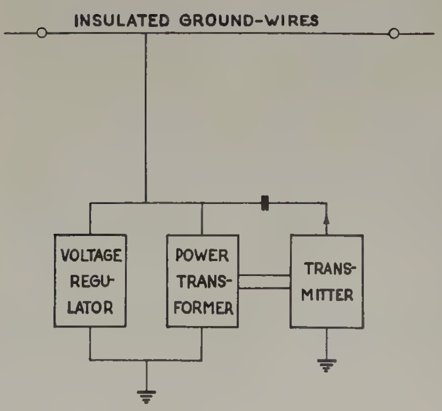

Fig. 2. Block diagrams showing the line radio transmitter connected to the ground wires and the power supply for the transmitter from the ground wires

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Digest of paper 54-212, "Radio Transmission on 230- and 400-Kv Lines in Sweden," recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Summer and Pacific General Meeting, Los Angeles, Calif., June 21–25, 1954. Published in AIEE *Power Apparatus and Systems*, August 1954, pp. 1037–40.

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Characteristics of Magnetic Amplifiers for Industrial Use

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The advantages and disadvantages of self-saturating magnetic amplifiers for use with industrial-type regulators are discussed. Some of the methods which may be utilized to overcome the undesirable characteristics of the magnetic amplifier also receive attention.

THE application of self-saturating magnetic amplifiers to industrial-type regulators is the specific aspect of magnetic amplifiers which will be discussed. This distinction is made since a particular philosophy exists in industrial regulator design where only a small number of units are manufactured as opposed to some military device, where thousands of a particular unit may be manufactured to the same design.

The manner in which the characteristics of the magnetic amplifier adapt themselves to regulator design is indicated. The magnetic amplifier has many well publicized advantages which make it desirable for industrial use. The magnetic amplifier also has certain undesirable characteristics which have not been well publicized. This has brought about some unfortunate experiences to many who have attempted to apply magnetic amplifiers. It is also the purpose of this article to show some of the methods that may be used to overcome the undesirable features of the magnetic amplifier. Although the inherent disadvantages can be met with only slight sacrifices for many applications, there are some applications in which the magnetic amplifier cannot conveniently be used.

ADVANTAGES

THE many advantages of magnetic amplifiers have been well treated in previous literature. Therefore, merely a summary of the advantages is included here. The magnetic amplifier is completely static, is rugged, and has long life. Maintenance is very low and shock or vibration does not affect a magnetic amplifier's characteristics. Although these amplifiers are relatively new, their components, reactors, and rectifiers, have already proven that they have many years of life.

Magnetic amplifiers may be mounted in control panels. This results in considerable savings to the purchaser as compared to rotating amplifiers since foundations, mounting, and conduits for auxiliary motor-generator sets are eliminated. Panel mounting allows more testing at the factory with some saving in installation time and expense.

A single-stage 60-cycle magnetic amplifier has a higher figure of merit (power gain per second of time constant) than any single-stage rotating amplifier. In sizes below 200 watts, they have a higher figure of merit than the amplidyne which is a 2-stage rotating amplifier.

In sizes below 100 watts, the magnetic amplifier has been found to be less expensive than a rotating amplifier. Above this rating, each application must be considered separately. For some applications, as is explained later, the magnetic amplifier must be severely derated. The availability of auxiliary motor-generator sets for mounting an amplidyne must also be considered. In certain cases, application of magnetic amplifiers of several kilowatts is entirely practical.

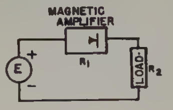
OTHER ADVANTAGES

1. These amplifiers with low-turn control windings will easily amplify low-voltage signals as from a shunt or thermocouple.
2. Magnetic amplifiers may be biased off beyond the minimum point and thus provide a nonlinear amplifier with desirable features for special applications like current limit. A small control signal has no effect, but a large signal will change the amplifier output.
3. Residual in a rotating amplifier is a handicap which is eliminated by substituting magnetic amplifiers.
4. Use of 400- to 2,000-cycle power supply results in very much faster amplifiers, primarily because the reactors are physically small. The figure of merit increases with the frequency of the power supply.

DISADVANTAGES

MAGNETIC AMPLIFIERS have an unidirectional output, but even more limiting is the fact that a very low direct voltage in series with the output will saturate the reactor and cause current flow. Thus, in Fig. 1, the load current will be $E/(R1 + R2)$ even though the magnetic amplifier is biased off. The box with the rectifier inside is used as a symbol for the power circuit of a magnetic amplifier. All self-saturating d-c magnetic amplifier circuits, both single- and 3-phase, have the same limitations unless specifically noted. The a-c output circuit followed by a full wave rectifier (Fig. 8) is classified as a d-c circuit in this article.

The reversing circuit of Fig. 2 seems feasible but cannot



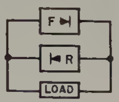


Fig. 1 (left). A series voltage will saturate a magnetic amplifier. Fig. 2 (right). An impractical reversing circuit

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Revised text of a conference paper presented at the AIEE Winter General Meeting, New York, N. Y., January 18–22, 1954, and recommended for publication by the AIEE Committee on Industrial Control and AIEE Committee on Mining and Metal Industry.

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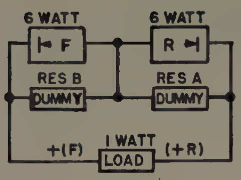
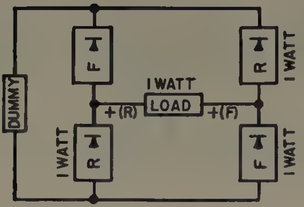
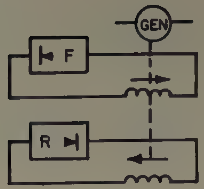






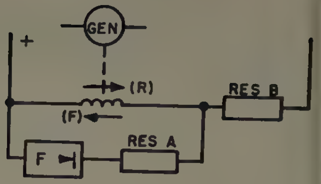
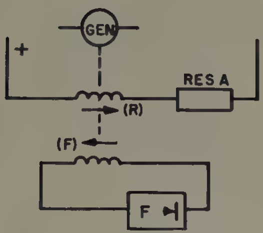
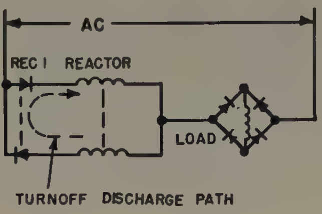
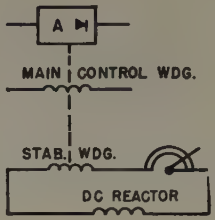


Fig. 3 (far left). Simple reversing circuit for one load. Fig. 4 (left). Alternate reversing circuit for one load. Fig. 5 (right). Reversing circuit with two loads. Fig. 6 (far right). Negative excitation on main field







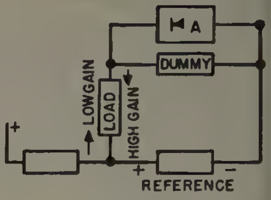


Fig. 7 (far left). Negative excitationon auxiliary field. Fig. 8 (left). A-c circuit supplying d-c load. Fig. 10 (right). Reactor stabilizing circuit. Fig. 11 (far right). Voltage matching circuit

be used because of the characteristics described. If the forward amplifier is turned on, it applies a voltage to the reverse unit and causes a short circuit.

For full reversing on a single load, resistor networks such as Fig. 3 must be used. This is so inefficient that it is only practical in small sizes, since the total magnetic amplifier rating must be 12 times the load power. Circuits such as Fig. 4 introduce a resistor voltage in series with the unwanted amplifier to prevent its firing. These circuits have better steady state efficiency (4 to 1) but are considerably more complicated.

Efficient reversing operation can be obtained only by supplying separate loads for each amplifier as in Fig. 5. Again this is economical only for small generators since the generator size must be increased to accomodate the two 100-per-cent fields. Even if the application has a duty cycle such that two 50-per-cent field windings in a standard size generator are adequate, it can be shown that each magnetic amplifier must be twice the power rating of an equivalent single rotating amplifier supplying one field.

REGENERATIVE STOPPING

This same limitation of magnetic amplifiers is a disadvantage for regenerative stopping. If a drive is nonreversing, a single amplifier is sufficient for steady state operation, but one amplifier cannot stop the drive quickly. Referring back to Fig. 1, if the load is inductive, it will supply a voltage as its current decreases in the same polarity as the illustrated generator. Therefore, the magnetic amplifier continues to conduct and the inductive current will decay on its normal time constant.

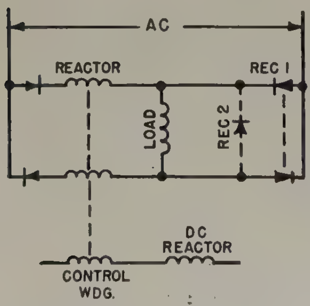


Fig. 9. D-c bridge circuit with components that may be added to prevent snapping

Therefore, fast stops require two magnetic amplifiers and the inefficient circuits of Fig. 3 or 5. As the reverse amplifier is used infrequently, these circuits can be unbalanced to take advantage of the duty cycle. In Fig. 3 Resistor *A* can be low and Resistor *B* high which will give the forward amplifier a fair efficiency. In Fig. 5 the reverse field need be only 10 to 20 per cent winding space, but the peak kilowatts required on the reverse amplifier will be surprisingly high because the forward field is short circuited.

For slower stops the reverse amplifier can be replaced by a fixed negative excitation. For this Figs. 3 and 5 reduce to Figs. 6 and 7. Further economies are possible if a rheostat is available to program the negative excitation.

MINOR PROBLEMS

The forementioned advantages and disadvantages will usually determine whether a magnetic amplifier should be used. However, the designer's job is not finished. There are a number of minor obstacles to overcome.

1. An inductive load will cause a d-c output magnetic amplifier to "snap" causing a sudden jump in the output as excitation is changed. One solution is to use an a-c output amplifier followed by full wave rectifier as shown in Fig. 8. The balanced discharge path for the load causes it to act as a resistor load. However this amplifier will not "turn-off" as fast as the d-c output circuits because of the discharge path noted in Fig. 8.

Other solutions are based on the bridge circuit of Fig. 9. Rectifier *1* supplies a fair discharge path for the load and combined with high control circuit impedance, this circuit will not snap. Reactors which add very little to the time constant, can be used to provide high control circuit impedance. In addition Rectifier *2* can be added to lower the required impedance.

2. As the output of a magnetic amplifier changes considerably more with alternating voltage than does a rotating amplifier, it requires higher system gains.

3. With no control signal a magnetic amplifier is turned on. Therefore, for most industrial applications, a negative excitation bias winding is required to provide minimum output with no external signal.

4. Extra control equipment may be required to eliminate the amplifier minimum output. Fig. 6 can be used to cancel the minimum output.

5. The voltage waveshape of these devices is very poor. This is a severe handicap for limit circuits and other circuits containing rectifiers. Filters must be used which add additional load, an undesirable phase shift and voltage drop, and extra equipment.

6. Many systems, or internal feedback loops of systems are best stabilized using rate feedback around an amplifier. However, very little rate feedback can be used on a single-phase magnetic amplifier without a filter for the 120-cycle ripple. Reactor stabilizing, shown in Fig. 10, has many of the same characteristics as rate feedback, but it is not as powerful or flexible as rate feedback on an amplidyne.

7. A well-laminated inductive load causes resonant voltage peaks to appear across the rectifiers. A small condenser in series with a resistor placed across the load will supply a discharge path for this high-frequency transient.

8. Buck-boost circuits and circuits matching the output against other voltages require dummy resistors to complete the circuit for negative currents, see Fig. 11. This circuit is inefficient and has a different gain for each direction of current flow.

9. Loss of alternating voltage poses a serious problem for some systems with magnetic amplifiers.

SPECIFICATION FOR AN INDUSTRIAL MAGNETIC AMPLIFIER

A magnetic amplifier for general use in industrial regulators should incorporate certain design features.

1. A group of standard units should be available which will adequately cover the desired ratings, from 1 watt to several kilowatts.

2. If possible, a single versatile set of control windings should be chosen for each rating. In order to make this feasible, the standard group of control windings must be carefully chosen. That is, the group should have four or five windings of large ampere-turn capacity and with a variety of turns. It is necessary to have a large ampere-turn capacity in each winding so that large signals may be subtracted on separate windings.

3. From the system designer's viewpoint the use of a standard unit offers the additional advantage that the characteristics of a predesigned unit are well known to the designer and he can more easily and more quickly apply the unit to a special application.

4. The control windings of standard units should be designed for the higher operating voltages so that they are equally applicable to 600-volt circuits as well as low-voltage systems. This means that creepage distance and insulation levels should be suitable for 600 volts or higher.

5. The standard units should be produced as a package complete with reactor and rectifier so that a user need order only one device which is factory assembled. Thus, the problem of ordering and mounting the magnetic amplifier is much simplified.

6. The industrial magnetic amplifier should have as high gain as practical without sacrificing economy or interchangeability. Most industrial regulators do not require high gain, but in the cases where the high gain is required, a preamplifier can be used with very small increase in cost.

A standard line of magnetic amplifiers has recently been produced incorporating these features in ratings from 1 volt-ampere to 4.7 kilovolt-amperes. Four of these units are shown in Fig. 12.

MAGNETIC AMPLIFIER APPLICATIONS

The importance of the shortcomings of magnetic amplifiers depends upon the application. For some applications, the disadvantages listed earlier may not apply. In like manner, other applications may require such a considerable sacrifice of performance, economy, or simplicity, that the advantages of using the magnetic amplifier are lost. In between these extremes, of course, lies the problem as it must be decided for each case if the gains justify the sacrifices.

Preamplifiers. When the magnetic amplifier is used as a preamplifier, there are many circuits which may be used since high efficiency is not important. A regulator with and without preamplifier is illustrated in Figs. 13 and 14. These circuits represent actual applications as closely as possible. The first example is a single amplidyne voltage regulator with typical circuit adjustments. It may be seen that this system has a gain of 22, a control field time constant of 0.1 second, and an input impedance of 183 ohms. The second example shows how this system may be improved by the addition of a magnetic amplifier preamplifier. The new system gain is 50, the amplidyne control time constant is 0.015 second, the magnetic amplifier time constant is 0.018 second, and the input impedance is 500 ohms. The advantages of using a magnetic amplifier preamplifier are clearly seen. The magnetic amplifier is relatively simple to apply in a system when it is to be used as a preamplifier since most of its limitations pose no problem. The major disadvantages of a magnetic amplifier (uni-directional output) is overcome by using two units in a buck-boost connection on two exciter fields. Since such preamplifier units are small, this is feasible.

There are so many applications in which the magnetic

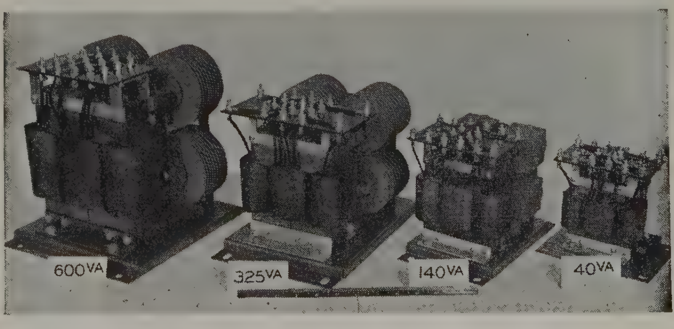


Fig. 12. Four ratings of General Electric standard line amplistats

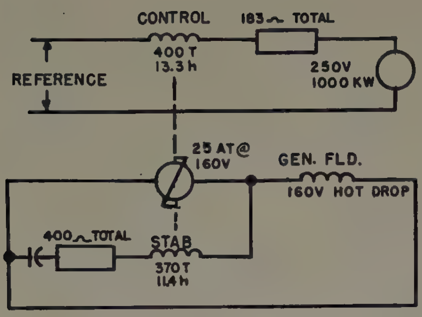
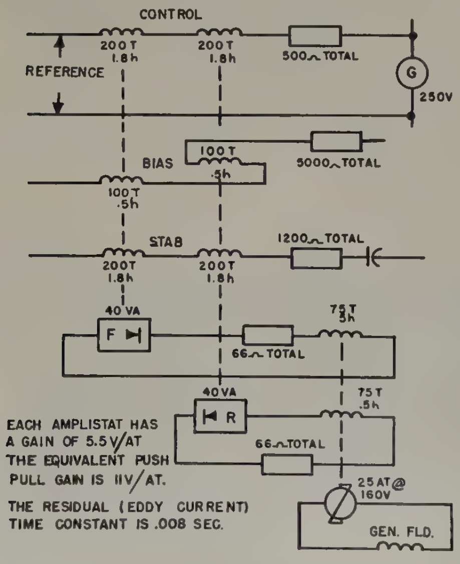


Fig. 13. Amplidyne voltage regulator. Error volts on control field: (25AT/400T)×183Ω=11.5V. Regulating system loop gain 250V/11.5V=22. Amplidyne control field time constant equals the sum of individual field L/R: T.C. = 13.3h/183Ω + 11.4h/400Ω=0.1 sec. Input impedance=183Ω

amplifier might be used as a preamplifier that it is impossible to make a comprehensive listing. However, some examples to illustrate its use may make the type of application clearer.

1. The magnetic amplifier preamplifier may be used to provide gain and increase the input impedance of a voltage regulator. Such a system has been successfully used in a reversing planer drive which was to be controlled from a pendant station. To make it possible to use small potentiometers for control, a magnetic amplifier was necessary to preamplify the small signals.
2. The magnetic amplifier has often been used to amplify current limit signals so that current may be more accurately limited. A magnetic amplifier was recently employed in this manner on a 12,000 hp blooming mill. It proved highly successful and allowed the control to be tuned for rapid reversals of 1 second at base speed and 2.5 seconds at top speed.
3. Such a preamplifier may also be used to amplify stabilizing signals, or to operate relays from a low-power signal.

Limited Range Regulators. Some voltage regulators serve to maintain a constant voltage while compensating for disturbances of load and speed, but are not required to regulate the voltage over a wide range. If size permits, a magnetic amplifier is easily utilized in a system of this type since the regulator need not reverse.



EACH AMPLISTAT HAS A GAIN OF 5.5V/AT THE EQUIVALENT PUSH PULL GAIN IS 11V/AT.

THE RESIDUAL (EDDY CURRENT) TIME CONSTANT IS .008 SEC.

Fig. 14. Voltage regulator with magnetic amplifier preamplifiers. The error voltage is determined as follows: 25AT/75T =1/3 amp, 1/3×66Ω=22V; 22V requires 2AT excitation on amplistats; (2AT/200T) ×(500Ω)=5V error signal. Regulating system loop gain: 250/5=50. Amplidyne control field time constant: T.C. = 0.5h/66Ω + 0.5h/66Ω = 0.015 sec. Amplistat time constant: 3.6h/500Ω+1h/5,000Ω+3.6h/1,200Ω +0.008=0.018 sec.

In this category falls the most frequent application of magnetic amplifiers: voltage regulators to control the alternating voltage of engine driven alternators for aircraft, railway equipment, etc. The magnetic amplifier ideally serves this application. Other applications of this nature are the excitation of induction heating generators and the excitation of the phase shifting network for power rectifiers.

Motor Field Current Regulators. There are numerous applications in which the excitation of a d-c motor must be quite accurately controlled. Such applications are well suited to the characteristics of the magnetic amplifier, since here again, the motor field excitation need not reverse.

One example of this type of application is a motor field regulator for a printing press drive. The motors of the drive are on a common bus, but to obtain rapid and accurate control a magnetic amplifier regulated the motor fields. Another example is a cold strip mill in which it is desired to have a means of quickly changing the motor field current at the operator's command. Here the magnetic amplifier can conveniently provide rapid and accurate control of the motor field current. There are many applications of tension reels in which the magnetic amplifier has been used to regulate the motor field current as the reel builds up. Such drives are found in practically all continuous process industries, paper, rubber, plastics, textiles, steel, etc.

Nonreversing Ward-Leonard Drives. The magnetic amplifier may be used to supply the field of a Ward-Leonard generator for a nonreversing drive. For this application, the cost of overcoming the "plugging" limitation of magnetic amplifiers must be weighed against the advantages brought about by their use. "How fast must the drive stop?" is the important question to be answered.

The exponential curve of Fig. 15 illustrates the importance of considering this problem. To stop a drive in a time equal to one generator time constant requires a negative field excitation voltage of 60 per cent of the forward drop. This will require two amplifiers and possibly two generator fields, thus adding much to the equipment cost. Stopping times of two or three time constants may prove more practical since less negative excitation is required. As seen by the curve, 16 per cent is required for a stop in two generator time constants; 6 per cent is required for a stop in three time constants. To provide this negative field excitation, the circuits of Fig. 6 or 7 may be used. Fig. 6 requires an oversize magnetic amplifier, while Fig. 7 requires an oversize generator to accommodate two fields.

Continuous steel mill processing line machines are small and are not capable of stopping the heavy coils in less than 5 seconds. The generator time constants are usually 1.5 to 2 seconds so magnetic amplifiers should prove popular in these applications. Conveyor lines for all types of material handling are nonreversing with stopping times suitable for the use of magnetic amplifiers. The stopping time of paper machines is not critical. They would, therefore, be good magnetic amplifier applications.

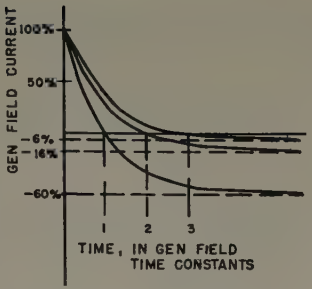


Fig. 15. Generator field decay curves

There are certain drives which have a high friction or work load so that dynamic braking may be used for fast stopping. For such a drive, a magnetic amplifier may be used since it would not need to produce negative excitation.

Reversing Ward-Leonard Drives. Magnetic amplifiers also may be economically applied to small reversing drives up to approximately 10 hp. Reversing drives require the inefficient and complicated circuits of Fig. 3 or 4 unless the oversize generator of Fig. 5 is used. These circuits are too expensive compared to a rotating amplifier for all but the smallest drives.

Steel mill processing line looper cars which move in and out to store material in a loop have a favorable reversing duty cycle and are small enough for consideration of magnetic amplifiers.

Many regulating boosters on these processing lines are reversing but are small and have light duty cycles. They should be good magnetic amplifier applications.

Machine tool drives, and some elevators and hoists are normally stopped before reversing and thus may be reversed by contactors. Magnetic amplifiers can be used for these applications.

High-Frequency Magnetic Amplifiers. High-frequency magnetic amplifiers (400 cycles or higher) have a faster response than rotating amplifiers. Such units are sometimes feasible for large equipments requiring precision control. Faster amplifiers will permit a faster and higher gain system, with simplified stability adjustments.

These drives should be analyzed on a computer to be certain that the response will be sufficiently increased to warrant the extra expense and complication. With three or more important system time constants, the amplifier time constant should be less than the other system time constants. However, as the amplifier time constant is reduced further below the other major system time constants, no startling system improvement will be noted.

Ripple, "hash," or "noise" are other reasons for not using high frequency magnetic amplifiers. A slower amplifier is just as good as a fast amplifier which is preceded by the long time constant of a "hash" filter. Gear backlash is another limitation on system speed. Systems must be slowed down to eliminate instability due to backlash.

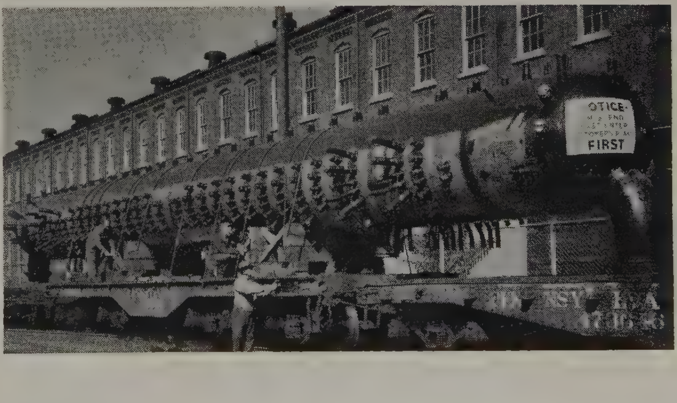
CONCLUSION

Based upon the reasoning given in the foregoing discussion of magnetic amplifier characteristics and applications, it appears that this amplifier has many uses in regulating circuits. However, it should not be considered the answer for every application. When a low power preamplifier is required, the magnetic amplifier should be considered since it incorporates the advantage of low cost and good performance. For an application in which the regulator need not provide negative excitation, as in a limited range voltage or a motor field current regulator, the magnetic amplifier should serve very well. The magnetic amplifier is easily applied since its nonreversing characteristic is of no disadvantage. When the regulator must force to zero as in a nonreversing Ward-Leonard drive, the ease with which the magnetic amplifier may be applied depends mainly on the stopping time of the drive. If the voltage may be reduced to zero reasonably slowly, the magnetic amplifier will often fit neatly into the application. Only on the very smallest drives can the magnetic amplifier be economically used for reversing duty. Most reversing drives should consider the magnetic amplifier for preamplifier service only. If it is desired to obtain a regulator which has shorter time constants than existing rotating exciters, high frequency magnetic amplifiers may be used. This may occasionally be desired even at the sacrifice of economy and simplicity to obtain a rapid speed of response.

Largest Steam Boiler Is 15 Stories High

A 193-ton steam drum, built by The Babcock & Wilcox Company at its Barberton, Ohio, plant will become part of the largest single boiler ever built in the world. The giant boiler, which will reach 15 stories in height when erected, will supply steam for the first of 2 turbine generating units to be installed at the River Rouge power plant of The Detroit Edison Company. Each unit will have a maximum capacity of 273,000 kw, enough electricity to supply the needs of over 700,000 people.

The drum is one of the most unusual welded pressure vessels ever built. It is 82 feet long and the thickness of its steels walls measures almost 6 inches. The boiler will consume more than 400,000 tons of coal each year. It will produce a maximum of 1,720,000 pounds of steam per hour, and deliver it to the turbine at 2,000 pounds per square inch.



The giant 82-foot 193-ton drum, which is to be part of the world's largest boiler, required 3 railroad flat cars for its trip to the River Rouge plant of the Detroit Edison Company

Automatic Paralleling of Aircraft A-C Generators

M. J. POWELL
ASSOCIATE MEMBER AIEE

E. W. GILOY
ASSOCIATE MEMBER AIEE

THE EVER-increasing complexities of aircraft as dictated by operational and functional requirements make it desirable, if not necessary in certain cases, to relieve the airplane crew of manual control of many functions of aircraft operation. Particularly this is considered to be the case for certain control operations of paralleled a-c power systems. The act of synchronizing and paralleling a-c generators by manual means can require the attention of a crew member when other duties are most demanding of his time and if performed improperly may result in undesirable transients and improper operation of the system.

As design criteria for automatic paralleling systems it is proposed that:

1. It is desirable to limit the maximum transient disturbance to generator full load current, with the transient voltage within the limits defined by the military aircraft power specification *MIL-E-7894*.
2. The performance, from the time of the initial adjustment until a service overhaul is required, of a properly operated system should maintain the difference in load (both real and reactive) between the generator with the greatest load and the generator with the smallest load within 10 per cent of a single generator rating (watts and vars).

When an a-c generator is paralleled with the bus, the bus voltage transient, inrush current, and torque developed at the instant of breaker closing are determined by the phase angle between the voltage of the oncoming machine and that of the bus, the voltage difference between them, and the internal impedance of the generators. These values are also affected by the frequency error and the number of machines initially on the bus. Transient values obtained from tests on a system using two 40-kva a-c generators driven by mechanical-hydraulic differential-type drives; and subtransient values calculated for a system with as many as four generators indicates that for a 4-generator system to meet the requirements of the first paralleling criterion, the synchronizing angle should probably be held to a maximum of 30° to 35°. This value of synchronizing angle assumes that the bus and generator voltages are equal in magnitude; however, a difference in scalar magnitude of even 5 or 6 volts, when based on a phase voltage of 115, will be small compared to voltage differences due to a phase-angle error. Hence its effect on the transient disturbance will be small. The frequency error, within reasonable limits, at the time of paralleling is, likewise, not too important if overrunning clutches are used, but it does mean that a "fast" machine, when paralleled, will attempt to take all of the load. The frequency error does, however, determine the time available for sensing the phase angle and closing the necessary control gear to connect the oncoming generator and bus in parallel. If a phase-angle difference of 30° (allowing 50 milliseconds as the time required for necessary control equipment operation) is to be held, a simple calculation will show that the bus and generator frequency difference cannot exceed 3 cycles.

If maximum benefits are to be obtained from an automatic paralleling system, the initial frequency and voltage settings should be held within limits that will allow the generators, as controlled by the load division circuits, to share the bus load within the accuracy defined by the second design criterion. To obtain this desired load division, without manual adjustments after paralleling, on a 2-generator system presently in use, tests indicate that the generator voltages cannot be different by more than 0.75 volt and the frequencies cannot be different by more than 0.75 cycle per second. An over-all improvement of the regulation accuracy of system voltage and frequency control equipment and of system load sharing control strength will be required to obtain the over-all objectives of autoparalleling systems.

In considering general methods of obtaining automatic paralleling for aircraft a-c systems, one will be confronted with the different presently used methods of constant-speed-drive governing which will probably preclude the development of a single method of automatic synchronizing adaptable to all systems. Therefore, as an interim expedient, it is suggested that a manual synchronizing-automatic paralleling system be considered wherein a device can be used to sense when generator and bus voltage phase relationships are proper and to close automatically the "incoming" generator to the bus without involving or affecting the different methods of drive governing. In using this method of paralleling it will only be necessary for the system operator to vary the frequency of the "incoming" generator until it closely approaches or passes through the frequency setting of the bus. At this time, the phase-sensing device can automatically connect the "incoming" generator to the bus at the desired synchronizing angle. Some readjustment of voltage and frequency settings will perhaps be required after paralleling to equalize generator loads when this device is used on present a-c systems. However, a completely automatic paralleling system will be realized when this device is applied to a system that utilizes generator drives (including over-running clutches) and voltage regulators that have been designed and developed so that, for all speed, load, and environmental conditions, generator frequency and voltage deviations from that of the bus will not preclude automatic load sharing within the desired limits.

Digest of paper 54-312, "Considerations Applicable to Automatic Paralleling of Aircraft A-C Generators," recommended by the AIEE Committee on Air Transportation and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Summer and Pacific General Meeting, Los Angeles, Calif., June 21–25, 1954. Scheduled for publication in AIEE *Applications and Industry*, 1954.

M. J. Powell and **E. W. Giloy** are with the Glenn L. Martin Company, Baltimore, Md.

Control of Speed and Cut in a Continuous Process Line

E. G. ANGER
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WALLBOARD and plasterboard as used in the fabrication of modern homes is produced on a continuous process line. It consists of a forming station, several belt sections used for curing and drying, a live roll section used to dry the underside, a punch and knife section used to pierce holes and cut the board to length, an oven curing section, and a trimming and packaging section. In this line an upper and lower layer of paper is used to make an envelope containing a material resembling plaster of Paris. This material starts as a mud, and is cured and dryed in the process. The board is formed and cut to proper length. In order to prevent a loop from forming between belt sections or to prevent the belt sections from tearing the board, the adjacent belt sections should be controlled in speed with respect to each other to within 1 part in 3,000, or to a maximum permissible inaccuracy of 0.03 per cent.

Similar accuracy is required at the knife station where the board is cut to length. Here an inaccuracy of ±1/32 inch on a 16-foot board length is permitted. The line speed itself is controlled to ±1/2 foot per minute on a maximum line speed of 100 feet per minute. This speed control is needed to limit the variation in the curing cycle as the board hardens, and to provide proper co-ordination at the forming station where the line speed must accommodate a constant flow of mud being made for the board.

Since the tolerance in speed matching is so limited, conventional tachometer speed comparison is not deemed adequate. A new approach is offered which employs d-c motors in an adjustable drive system using a common d-c generator to drive the entire line.

Intersection co-ordination is accomplished by using control synchros. A control synchro transmitter is driven by each belt motor. Also driven by the belt motor is an adjustable ratio transmission which turns another synchro, feeding in a speed differential between the 2-belt transmitting synchros. A fourth synchro element, the receiver, connected in series, is mechanically connected to a small potentiometer which controls the relative field strength of the belt section drive motors.

With this control scheme the second belt section then runs at an average speed which is equal to that of the first belt plus the feed differential being fed in by the adjustable ratio gear box. The maximum difference which can be fed in by this arrangement is chosen as 3 per cent. Any error in the adjustable gear box can then affect only the speed difference rather than the total speed. By choice of a precision built unit, control of this difference can be held to within a small fraction of 1 part in 100. Since the synchro units control the 2-belt sections as a position regulator, the only inaccuracies remaining are in the adjustable ratio transmission. This combination makes it possible to achieve intersection co-ordination on the basis of 1 part in 3,000 or better.

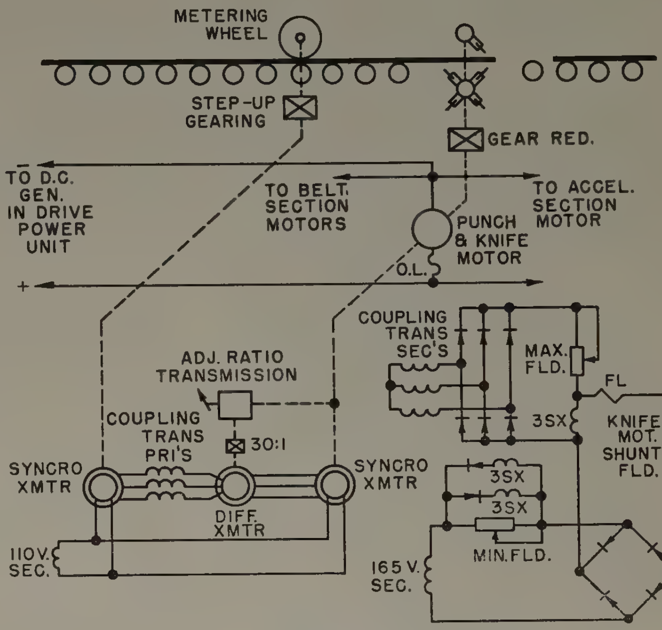


Fig. 1. Diagram of knife regulator

A forcing scheme is used to cut the board to length, see Fig. 1. A metering wheel riding the board drives a synchro transmitter. The knife motor drives the other synchro transmitter, adjustable transmission, and differential synchro. The rotary type knife is held in synchronism with the board speed similar to the system described for belt regulation except that instead of using a receiver for a synchro, a set of transformers is connected to receive a signal and feed it into a magnetic amplifier, which in turn controls the field of the knife motor. Adjustment of board length is accomplished by adjustment of the adjustable ratio transmission which in turn controls the relative speed of the knives with respect to the board. The board is cut to length with an accuracy such that variations in length are not detected by a steel tape.

It will be observed that intersection co-ordination as well as length of cut at the knife continues to function as the line speed is adjusted by control of the common generator voltage. Once adjusted, tachometer feed control holds the speed to ±1/2 foot per minute.

Heretofore power synchro drives were used with adjustable ratio power transmission. Occasionally these units being operated against field rotation would start up in reverse. Adjustable ratio power drives would develop worn grooves in the position regularly used making minor speed corrections difficult or impossible to obtain. The employment of d-c motors eliminated these difficulties, while it added simple control of over-all line speed.

Digest of paper 54-387, "Accurate Control of Relative Speed and Cut in a Continuous Process Line," recommended by the AIEE Committee on Industrial Control and approved by the AIEE Committee on Technical Operations for presentation at the Fall General Meeting, Chicago, Ill., October 11–15, 1954. Scheduled for publication in *AIEE Applications and Industry*, 1954.

E. G. Anger and **D. L. Pettit** are both with the Square D Company, Milwaukee, Wis.

5,000 Registrants Expected at 1955 Winter General Meeting

It is expected that last January's record registration of 5,000 members and guests will be repeated at AIEE's 1955 Winter General Meeting. Ninety technical sessions and conferences are also anticipated for the meeting which will be held January 31–February 4 in New York, N. Y., at the Hotels Statler and Governor Clinton.

TECHNICAL SESSIONS

It is still too early for a definite report on the committees sponsoring technical sessions. However, it may be assumed that most of the 40 committees in the five technical divisions will be represented. More information will be in December's *Electrical Engineering*.

HOTEL RESERVATIONS

Blocks of rooms have been set aside at the Hotel Statler (meeting headquarters) and nearby hotels for members and guests. Requests for reservations should be sent prior to January 17, directly to the hotel of choice and to only one hotel. AIEE should be mentioned in the request and a copy sent to D. V. Buchanan, vice-chairman of the Hotel Accommodations Committee, Room AU16, Consolidated Edison Company of New York, Inc., 4 Irving Place, New York 3, N. Y. A second and third choice should be noted on this copy.

Because of the current accommodations situation in New York hotels, reservations for arrival on Sunday, January 30, are suggested. If accommodations at the hotel requested are not available, the Hotel Accommodations Committee will transfer the request to one of the other hotels.

THEATER TICKETS

Theater tickets will be provided for members who want to see stage shows. However, the committee under the chairmanship of S. Friend, Jr., feels it is inadvisable at this time to give a specific listing of the stage shows that will be playing during the meeting. A complete listing of the shows is scheduled for the December issue, and it is requested that all inquiries be deferred until that time.

Tickets to available radio broadcasts and television shows also will be provided at the time of registration.

SMOKER COMMITTEE

A smoker is scheduled for Tuesday evening, February 1. Attention is called to the fact that the smoker will be held at the Hotel Statler rather than at the Hotel Commodore as in recent years. Tickets will be $10.00 each. Reservations should be made at an early date and addressed to: Smoker Committee, AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.

DINNER-DANCE

A Dinner-Dance will be held Thursday evening, February 3, in the Grand Ballroom of the Hotel Statler. General arrangements will be the same as those which proved so enjoyable last year. Dress will be formal. Plan now, and write soon for reservations at tables for ten. Address requests to: Dinner-Dance Committee, Avery H. Gould, Chairman, AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.

INSPECTION TRIPS

An interesting program of inspection trips is being prepared. In addition to new trips some of the more popular trips of past meetings may be rescheduled including Radio City Music Hall, Federal Electric Products, and Brookhaven National Laboratory.

LADIES ENTERTAINMENT

The Ladies Entertainment Committee, under the chairmanship of Mrs. Merwin Brandon, is planning a varied program. On Monday, there will be the usual "Get Acquainted Tea." A dinner, a fashion show and luncheon, plus several tours are scheduled.

WINTER GENERAL MEETING COMMITTEE

Members of the 1955 Winter General Meeting Committee are: A. J. Cooper, chairman; D. M. Quick, vice-chairman; J. J. Anderson, secretary; C. S. Purnell, budget co-ordinator; J. P. Neubauer, Vice-President, District 3; J. D. Tebo, chairman, Committee on Technical Operations; R. T. Ferris, public relations; J. R. Kerner, general session; Avery Gould, dinner-dance; W. G. Vieth, hotel accommodations; J. V. O'Connor, inspection trips; Morris Brenner, registration; R. W. Gillette, smoker; R. T. Weil, monitors; S. Friend, Jr., theater and broadcast tickets; Mrs. Merwin Brandon, ladies' committee; C. T. Hatcher, ex officio member (past chairman).

Conference Papers Available Beginning with Winter Meeting

The problem of the conference paper has been before the Institute for many years and present methods of handling this type of paper have proved to be unsatisfactory. The chief difficulty has been that a great many members who are unable to attend meetings cannot obtain copies of conference papers. The problem has been under study for several years by the Committee on Technical Operations and the Publication Committee. Surveys have been made at several large meetings to determine the willingness of the authors to furnish copies and the probable demand for the papers. As a result of these studies, the following policy for all conference papers to be presented at the general meetings, district meetings, and special technical conferences will become effective beginning with the papers for the Winter General Meeting.

An abstract or outline of all conference papers is required by the sponsoring committee chairman or the Assistant Secretary for Technical Papers 75 days or more in advance of meetings (for the Winter General Meeting by November 17).

All conference papers received by the Assistant Secretary for Technical Papers 60 days in advance of meetings (by December 2 for the Winter Meeting) will be duplicated and distributed by the Institute in the same way as Transactions papers, provided the manuscripts and illustrations have been prepared in AIEE style as explained and illustrated in the "Author's Guide." One original single-spaced typewritten copy typed on one side only with original illustrations and one duplicate illustrated copy should be submitted.

Authors of late conference papers will be requested to bring a quantity of duplicate copies to the meeting which will be sold by the Institute at regular prices, 30¢ to members; 60¢ to nonmembers. There will be no direct distribution of papers by authors.

Success Assured on First Day of Middle Eastern District Meeting

As this issue goes to press the Middle Eastern District Meeting in Reading, Pa., October 5–7, 1954, with headquarters in the Abraham Lincoln Hotel, has just convened. With a registered attendance of 454 by noon of the first day and with a technical program of 20 sessions to follow, the ultimate success of the meeting is assured.

The highlight of the General Session was the address, "An Electrifying Future" by William V. O'Brien, vice-president, General Electric Company and general manager of the Apparatus Sales Division. Speaking from a wealth of experience as a former manager of the Wire and Cable Division and Central Station Divisions, Mr. O'Brien forecast a remarkable period of growth for the electrical industry in the years ahead. His address will appear in a later issue of *Electrical Engineering*.

President A. C. Monteith reviewed the history and growth of the Institute over the past 30 years with reference to the increase in the number of members, the Sections, and Student Branches, as well as the activities and services rendered. During that period of time, the dues had never been increased; but during the past year there was an operating deficit of approximately $40,000 and there is now an estimated deficit of $70,000 for the forthcoming year. The matter will be given serious consideration by the Board of Directors at its meeting in Chicago on October 14, and they might find it necessary to raise the dues. President Monteith also drew attention to the employment questionnaire distributed to all members in the United States last month. He urged that thoughtful and prompt attention be given to filling in and returning the questionnaires.

Vice-President W. B. Morton presented the District First Prize to Harris M. Joseph and Leslie S. G. Kovasznay for their paper, "Image Processing;" and the Second Prize to J. K. Dillard and C. J. Baldwin for their paper, "Rectifier Arc Back on Analogue Computer." R. E. Neidig, vice-chairman of the meeting, presided.

Following the General Session, a luncheon was held at which Mr. F. H. Lichtenwalter, formerly managing director of the Pennsylvania Electric Association, gave an interesting and constructive talk on how engineers should be active in their communities and take part in civic affairs. The speaker was introduced by Presiding Officer George Keenan, vice-president in charge of engineering, Pennsylvania Power and Light Company.

During the remainder of the meeting, 20 technical sessions will be held on subjects appropriate for the region in which the meeting is held, such as mining and quarrying, power, steel, textiles, industrials, television, telemetering and supervisory control, power transmission and distribution, substations, management, power plant safety, and atomic energy.

Future AIEE Meetings

Mid-Atlantic Textile Conference
North Carolina State College, Raleigh, N. C.
November 4–5, 1954
(Final date for submitting papers—closed)

AIEE-IRE Conference on Electrical Techniques in Medicine and Biology
Morrison Hotel, Chicago, Ill.
November 10–12, 1954
(Final date for submitting papers—closed)

AIEE-IRE-ACM Eastern Computer Conference
Bellevue-Stratford Hotel, Philadelphia, Pa.
December 8–10, 1954
(Final date for submitting papers—closed)

AIEE - IRE - NBS High-Frequency Measurements Conference
Hotel Statler, Washington, D. C.
January 17–19, 1955
(Final date for submitting papers—October 18)

Winter General Meeting
Hotel Statler, New York, N. Y.
January 31–February 4, 1955
(Final date for submitting papers—October 20)

Utilization of Aluminum Conference
William Penn Hotel, Pittsburgh, Pa.
March 15–17, 1955
(Final date for submitting papers—December 15)

Materials Handling Conference
Hotel Cleveland, Cleveland, Ohio
March 28–29, 1955
(Final date for submitting papers—December 28)

Southern District Meeting
St. Petersburg, Fla.
April 13–15, 1955
(Final date for submitting papers—January 12)

Middle Eastern District Meeting
Columbus, Ohio
May 4–6, 1955
(Final date for submitting papers—February 4)

Electric Heating Conference
LaSalle Hotel, Chicago, Ill.
May 10–11, 1955
(Final date for submitting papers—February 10)

1955 Summer General Meeting
New Ocean House, Swampscott, Mass.
June 27–July 1, 1955
(Final date for submitting papers—March 29)

Business Manager and His Assistant Retire After Half a Century of Service

Floyd A. Norris, AIEE Office Manager and Business Manager of the publications, retired October 30, 1954, after 50 years of service. His assistant, Harold B. Lewry, retired September 30, 1954, after 49 years of service. Both were devoted to their work, extremely conscientious, and untiring in their efforts during a period of remarkable Institute growth. Mr. Norris was instrumental in effecting methods to conduct work with a minimum staff to keep costs down during this period of great expansion.

Mr. Norris joined the AIEE headquarters staff in September 1904 when a boy at the age of 15. At that time, the staff consisted of ten members under the secretaryship of Ralph W. Pope and the Institute membership was 3,027—302.7 members to one member of the headquarters staff. Today the membership is over 48,000 and there are 58 headquarters staff members, or 827.6 members to one member of the headquarters staff. During his long tenure of service, Mr. Norris has been secretary to many of the General committees. In recent years, his work has been more closely associated with the Membership and Finance Committees, and he is Secretary of the Retirement System.

Residing in Hasbrouck Heights, N. J., Mr. Norris has been active in civic affairs. He served as a member of the Borough Council 1929–32, member of the Board of Education 1933–35, and is an Elder in The First Reformed Church in Hasbrouck Heights. His hobby is golf, and he is a former member of the Ridgewood Golf Club.

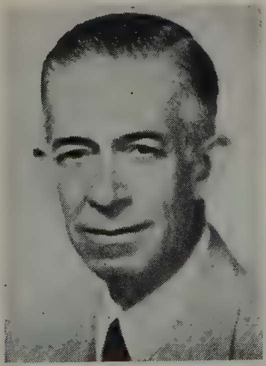
In respect to the retirement of Harold B. Lewry, his assistant and close associate for many years, Mr. Norris said:

"Mr. Lewry entered the employ of the Institute in September, 1905, to assist me in carrying out the duties of office boy; he has been my principal assistant ever since.

"Any description of his services would have to envisage the substantial growth of the organization over the past 49 years and the extent to which our services to the membership, to Sections, Branches, committees and others, have expanded in that time. In effecting what were considered to be the most practical and economic methods for each new activity which developed, Mr. Lewry proved to be a helpful and willing aide. Throughout his connection with the Institute he has held the esteem of all of his associates, and his conscientious attitude toward his work is evidenced by the fact that over his long term of employment he has not been absent from his job for more than a very few days. In Mr. Lewry's retirement the Institute is losing a valuable employee."

Mr. Lewry resides in Oradell, N. J. His chief hobbies are boating and fishing at his summer home in Shore Acres.

Retirement parties and gifts were given by staff members and associates at Institute headquarters in the Engineering Societies Building, New York, N. Y.



Floyd A. Norris

Harold B. Lewry

1954 Year Book Issued. The 1954 edition of the AIEE Year Book with addresses corrected as of May 1, 1954 has been issued. Copies have been distributed to all National, District, and Section officers, Student Branch counselors, and all members of National committees. Other members (exclusive of students) may obtain copies by writing to AIEE Headquarters, 33 West 39th Street, New York 18, N. Y. The Year Book is not available to enrolled students or nonmembers of the AIEE; nor is its use permitted for commercial, promotional, or circularizing purposes.

Eastern Joint Computer Conference to Be Held Next Month at Philadelphia

"Design and Application of Small Digital Computers" is the theme of the Eastern Joint Computer Conference and Exhibition to be held at the Bellevue-Stratford Hotel, Philadelphia, Pa., December 8, 9, and 10, 1954. Beside the AIEE, the sponsors are the Institute of Radio Engineers, and the Association for Computing Machinery.

The program includes papers on computer comparisons, input-output devices, computer systems and characteristics, mathematics, programming, and business and scientific applications. Three panel discussions on business applications, redundancy checking, and small computers as large computer auxiliaries are scheduled for Thursday afternoon.

On the social side, a cocktail party will be held Wednesday evening.

INSPECTION TRIPS

Inspection trips to the Bell System automatic message accounting center, Burroughs Research Center, the Franklin Institute network calculator, and Remington Rand's Ecker-Mauchly Division have been announced to date. Exhibits of about 60 companies will occupy the eighteenth floor of the hotel.

REGISTRATION

Preliminary programs and registration material have recently been mailed to all previous registrants, ACM members, and many AIEE and IRE members. Others may register at the conference, or request material by writing P. O. Box 7825, Philadelphia 1, Pa.

Preliminary program for the Conference follows:

Eastern Joint Computer Conference

Tentative Program

Wednesday, December 8

8:00 a.m. Registration

9:30 a.m. to 6:00 p.m. Exhibits

10:00 a.m. Morning Session

Chairman: H. R. J. Grosch, General Electric Company
Keynote Address: **Small Computers in a Large World.** *C. W. Adams*, Massachusetts Institute of Technology

Characteristics of Currently Available Small Digital Computers. *A. J. Perlis*, Purdue University

Why Not Try a Plugboard? *Rex Rice, Jr.*, Northrop Aircraft, Inc.

12:15 p.m. Luncheon

2:00 p.m. Afternoon Session

Chairman: H. T. Larson, Ramo-Wooldridge Corporation

Techniques for Increasing Storage Density of Magnetic Drum Systems. *H. W. Fuller, P. A. Husman, R. C. Kelner*, Laboratory for Electronics, Inc.

Application and Performance of Magnetic Core Circuits in Computing Systems. *R. D. Kodis*, Raytheon Manufacturing Company

A Self Checking High-Speed Printer. *Earl Masterson, Abraham Pressman*, Remington Rand, Inc.

Teletype High-Speed Tape Equipment and Systems. *W. P. Byrnes*, Teletype Corporation

6:00 p.m. Reception and Cocktail Party

Thursday, December 9

8:00 a.m. Registration

12:00 p.m. to 9:00 p.m. Exhibits

9:00 a.m. Morning Session

Chairman: J. H. Howard, Burroughs Corporation

Operating Characteristics of the National Cash Register Company's Decimal Computer CRC 102-D. *R. M. Hayes, A. D. Hestenes, L. P. Meissner*, National Cash Register Company

A Marchant Miniac Computer System. *G. B. Greene*, Marchant Research, Inc.

Performance of the TRADIC Transistor Digital Computer. *J. H. Felker*, Bell Telephone Laboratories

Application of a Burroughs E101 Computer. *Alex Orden*, Burroughs Corporation

12:15 p.m. Luncheon

2:00 p.m. Afternoon Session

Panel: Small Digital Computers and Business Applications. Chairman *W. D. Bell*, Mellonics; *W. L. Murdock*, General Electric Company; *B. B. Murdock*, Prudential Insurance Company

Panel: Redundancy Checking for Small Digital Computer. Chairman *R. W. Hamming*, Bell Laboratories; *Sibyl Rock*, Electrodata; *A. L. Samuel*, International Business Machines Corporation

Panel: Small Digital Computers to Assist Large Digital Computers. Chairman *J. W. Carr, III*, University of Michigan; *Walter Ramshaw*, United Aircraft Corporation; *John Lowe*, Douglas Aircraft Corporation

Friday, December 10

8:00 a.m. Registration

9:30 a.m. to 6:00 p.m. Exhibits

9:00 a.m. Morning Session

Chairman: A. S. Householder, Oak Ridge National Laboratory

Numerical Solution of Differential Equations. *H. M. Gurk, Morris Rubinoff*, University of Pennsylvania

Applications of Automatic Coding to Small Calculators. *L. D. Krider*, U. S. Naval Ordnance Laboratory

Automation of Information Retrieval. *J. W. Perry*, Battelle Memorial Institute

Message Storage and Processing with a Magnetic Drum. *A. P. Hendrickson, J. L. Hill, G. I. Williams*, Remington Rand, Inc.

12:15 p.m. Luncheon

2:00 p.m. Afternoon Session

Chairman: F. J. Maginniss, General Electric Company
Analysis of Business Application Problems on IBM 650 Magnetic Drum Data Processing Machine. *G. W. Petrie, III*, International Business Machines Corporation

Small Digital Computers and Automatic Optical Design. *N. A. Finkelstein*, Bausch and Lomb Optical Company

Computation of the Performance of Decision Element Circuits by Means of the IBM CPC. *B. F. Cheydleur*, Minnesota Electronics Corporation; *L. P. Giessler, H. L. Stevens*, U. S. Naval Ordnance Laboratory

San Francisco Section Tours New $14,000,000 Terminal

AIEE's San Francisco Section toured the new $14,000,000 San Francisco International Airport, August 14, 1954. This airport is served by 14 airline companies and ranks fifth in the United States in passengers accommodated and in air carrier movements. The new terminal is designed to handle 3,000,000 passengers in and out per year, and can accommodate up to about 5,000,000 passengers per year before added facilities for expansion are placed in service.

Formal public opening was August 27—almost two weeks after the Section's visit. Members had full opportunity to see all parts of the building and surrounding areas forbidden to the public, a complete behind-the-scenes look at all facilities from the control tower with its radio and radar equipment, through the passenger and baggage handling area, the telephone exchange, steam and power utilities, onto the field to the plane fueling and servicing areas.

The trip was a joint effort with the San Francisco Section of ASME. A record turnout of 395 registered, including 159 AIEE members, 105 ASME members, and 131 guests and students.

All arrangements were ably handled by Mr. A. J. Kritscher of the AIEE Technical Program Committee and assistant electrical engineer of the Public Utilities Commission of the City and County of San Francisco. Assisting Mr. Kritscher were Mr. T. M. Googin of Consolidated Purchasing and Designing, Inc., as chairman of the Industrial Technical Program Committee and Mr. F. W. Beickley of Westinghouse Electric Corp. as vice-chairman of the San Francisco Section of ASME.

Nuclear Engineering Committee Organized under EJC Sponsorship

The creation of the General Committee on Nuclear Engineering and Science, sponsored by Engineers Joint Council, has been announced. The new body has been established to "meet the pressing problems of nuclear engineering and the related sciences," with emphasis on the "industrial usefulness" of atomic power.

The Council is constituted of eight leading engineering societies with a total membership of 170,000. The American Chemical Society, which has joined the engineers in the nuclear unit, has 70,000 members. Dr. John R. Dunning, Dean of Engineering at Columbia University, has been elected chairman of the General Committee. Dr. Donald L. Katz, of the University of Michigan, is secretary and program chairman.

The General Committee on Nuclear Engineering and Science has invited the participation, as members, of organizations concerned with nuclear development.

A Nuclear Congress is planned by the General Committee to be held July 11–16, 1955, with an expected attendance of 1,500. Holding of this Congress is conditioned, however, by the action of the United Nations on Secretary of State Dulles' proposal for an international conference on creation of a world bank of fissionable material for peaceful productivity.

"It is the earnest desire of the General Committee on Nuclear Engineering and Science to co-operate fully with such a program," said the new committee's announcement. "If the United Nations designates a city in North America for a conference in 1955, we shall forego our own Nuclear Congress for that year and we shall be willing to accept the responsibilities for the civilian aspects of the meeting. If the UN conference is held abroad, our Nuclear Congress will be held in a city in the United States to be designated later."

Besides Dean Dunning and Professor Katz, members of the General Committee on Nuclear Engineering and Science include Alex D. Bailey of La Grange, Illinois, past president, American Society of Mechanical Engineers; Manson Benedict, professor of nuclear engineering, Massachusetts Institute of Technology; Raymond J. Faust, executive assistant secretary, American Water Works Association; Jewell M. Garrelts, professor and executive officer, Columbia University Department of Civil Engineering; Augustus B. Kinzel, director of research, Research Laboratory, Union Carbide and Carbon Company; D. C. MacMillan, president, George G. Sharpe, Inc.; Phillip N. Powers, director, Atomic Electric Project, Monsanto Chemical Company; Dr. J. C. Warner, president Carnegie Institute of Technology; Dr. Julian D. Tebo, science editor, Bell Telephone Laboratories.

420 Attend First Student Branch Meeting of the School Year

The Missouri School of Mines Joint Student Branch of AIEE-IRE opened the school year with its first meeting September 16, 1954. Campbell Barnds, chairman of the local branch, opened the meeting to more than 420 students, faculty members, and local television service men, with an introduction by Mr. Cyril N. Hoyler of the Radio Corporation of America. Mr. Hoyler, manager of technical relations for David Sarnoff Research Center, presented a demonstration-lecture, "The Principles of Color Television." Principles of color employed in the development of color television, and its history were reviewed. As the highlight of the evening, student members saw an actual demonstration of a color picture tube in operation.

The second meeting of the year, held September 23, was a freshman-sophomore smoker. This meeting was attended by more than 150 students. The Branch is looking forward to a successful year.

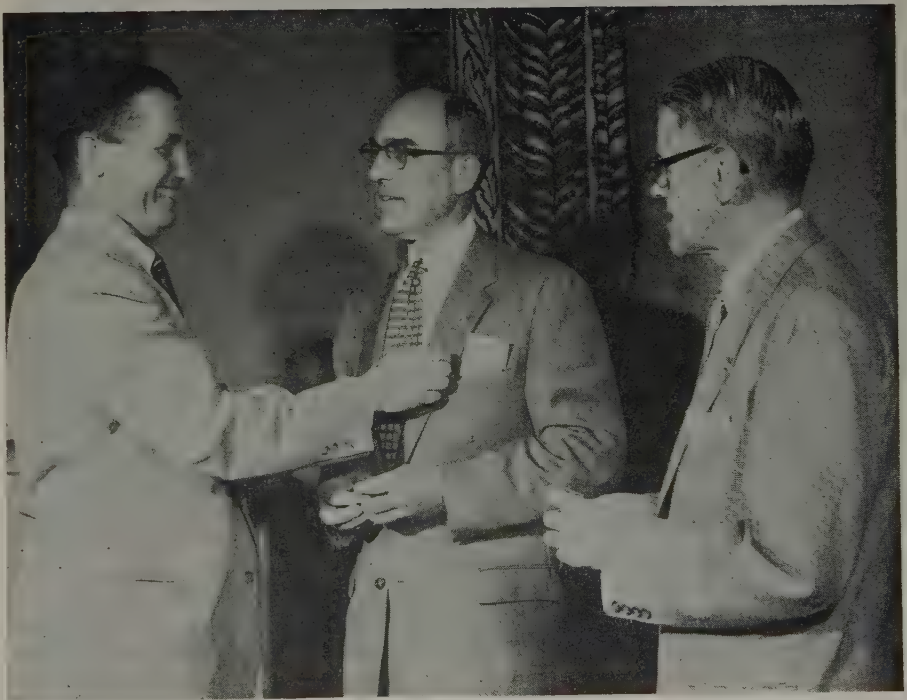
Michigan Section Honors Past Chairmen

Henry Crampton, assistant vice-president of the Michigan Bell Telephone Company, and A. P. Fugill, chief electrical engineer of Detroit Edison Company, were both honored at Michigan Section's first session this season, September 14. Crampton is immediate past chairman and Fugill served from 1952 to 1953. Presentation of past-chairman pins was made by J. J. Carey, current chairman.

The giant Kemano-Kitimat Power Link in British Columbia was discussed by the evening's principal speaker, F. L. French of the Aluminum Company of Canada.

New Erie Section Officers

New officers of AIEE's Erie Section have been inducted. Those taking office are shown above. Seated, left to right: G. H. Ramandanes, Pennsylvania Electric Company, chairman; T. J. Warrick, General Electric Company, secretary; and C. G. Moon, General Electric Company, vice-chairman. Standing, left to right: R. E. Anderson, Pennsylvania Telephone Corporation, treasurer; M. J. Kolhoff, General Electric Company, representative to Erie Engineers Societies Council. R. Lamborn, General Electric Company, past chairman, is at far right. He attended the Summer General Meeting in Los Angeles, Calif., and gave a report on the meeting at the induction ceremony. Section committee chairmen are now: Program, R. P. Ager; Membership, H. R. Stiger; F. D. Reese; D. J. Sitterson; R. A. Marelli; H. Vitt; K. C. Farver; M. W. Bellis



Michigan Section Chairman J. J. Carey presents past-chairman pin to Henry Crampton, vice-president of the Michigan Bell Telephone Company. A. P. Fugill, chief electrical engineer, Detroit Edison Company, (right) also received a pin as the 1952–53 chairman

Third UPADI Convention Is Reported by EJC

The practical effectiveness and good-will results of co-operative meetings of professional men of free nations were demonstrated at the Third Convention of UPADI (Union Pan-Americano de Asociaciones de Ingenieros or Pan American Federation of Engineering Societies), held in Sao Paulo, Brazil, August 2–6, 1954. This country was represented by 35 delegates and their guests under the aegis of Engineers Joint Council. Registrants were from 17 Western Hemisphere nations.

The convention adopted a resolution to reactivate the Pan American Committee on Standardization for development of an inter-American program of engineering standards. Headquarters for this committee will be in Rio de Janeiro. The convention also favored maintenance of liaison between UPADI and the Organization of American States, which has an office in Washington. It was recommended that each organization in UPADI seek, at home, to organize a consultive technical council for a study of the nation's resources with a view toward national works programs.

There was discussion on engineering education and the exchange of data on that subject among UPADI members. EJC has provided UPADI with information obtained from the U. S. Office of Education in Washington.

The next UPADI meeting will be in Mexico City in 1956. UPADI is a union of the principal engineering societies of most nations of the Western Hemisphere. Engineers Joint Council, the United States member, is composed of eight major engineering organizations with a total membership of 170,000.

The World Power Conference, held in Rio, July 25–August 10 drew 526 registrants, of whom 45 were from the United States. This organization, which has headquarters in London, is an association of organizations in the power field throughout the world. Many technical papers were presented by delegates from this country. The Rio meeting was regional. The next world-wide conference will be held in Vienna in 1956.

At the Third UPADI (Union Pan-Americano de Asociaciones de Ingenieros) Convention in Sao Paulo, Brazil, August 6, 1954, Engineers Joint Council presented a scroll to the Brazilian Federation of Engineering Societies. Gail Hathaway, a past president of the American Society of Civil Engineers, made the presentation for EJC. It was received by Saturnino de Brito on behalf of the Brazilian Federation of Engineering Societies. Shown above are (left to right): Ralph Morgen, research director of Purdue Research Foundation; Gail Hathaway, an employee holding the microphone behind the scroll; Saturnino de Brito; and H. L. Melvin, AIEE member and chief consulting engineer, engineering department, Ebasco Services, Inc., New York

IEE New Publication Arrangements for Journal and Proceedings

The Institution of Electrical Engineers in Great Britain has announced new publication arrangements effective January 1, 1955. Part I (General) of the *Proceedings* will be discontinued. The *Journal* will be designed to be of interest not only to members, but also to nonmembers who can now subscribe in the same way as for the *Proceedings.* In a more attractive form, the *Journal* will contain some of the general interest material at present appearing in Part I of *Proceedings.* The three parts of *Proceedings* will be as follows: *Part A, Power Engineering; Part B, Radio and Electronic Engineering;* and *Part C, Monographs.*

The *Journal* and the three parts of the *Proceedings* will be available to AIEE members at half the published rates as shown below.

Notice of the new arrangements has been sent directly to AIEE members who are at present subscribing to the *Proceedings.* They have been asked to complete new order forms and send them to: Nelson S. Hibshman, Secretary, AIEE, together with remittance for the appropriate subscription.

	Published rate	Reduced rate to members of co-operating societies
Journal	£1. 5s.0d. per annum	12s.6d. per annum
Proceedings Part A	£1.15s.0d. per annum	17s.6d. per annum
Proceedings Part B	£1.15s.0d. per annum	17s.6d. per annum
Proceedings Part C	15s.0d. per annum	7s.6d. per annum
Journal and all three Parts of the *Proceedings*	£5. 0s.0d. per annum	£2.10s.0d. per annum

COMMITTEE ACTIVITIES

Editor's Note: This department has been created for the convenience of the various AIEE technical committees and will include brief news reports of committee activities. Items for this department, which should be as short as possible, should be forwarded to R. S. Gardner at AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.

General Applications Division

Committee on Domestic and Commercial Applications (*T. C. Johnson, Chairman; H. F. Hoebel, Vice-Chairman; J. A. Deubel, Secretary*). The four Subcommittees on Heat Pumps and Electric Space Heating (East), Heat Pumps and Electric Space Heating (West), Domestic Appliances, and Farm Electrification are being continued for the coming year with essentially the same scope. Along with Heat Pumps, etc. recognition will be taken of the growing volume of domestic air conditioning and its attendant electrical load on the utilities.

In addition to the series of highly successful technical conferences on domestic appliances, the first technical conference on farm electrification will be held next March in Chicago, Ill.

The committee is trying to get wider representation in the fields of its interest throughout the industries, utilities, and educational institutions which are interested in its work.

Committee on Land Transportation (*P. H. Hatch, Chairman; R. L. Kimball, Vice-Chairman; F. E. Spindler, Secretary*). This committee faces an active year. Work on standards applicable to railway-type electric apparatus will be continued, as will general liaison work between the Committee, industry, and transportation agencies.

Attention will be given to the continuing problem of making the AIEE of more direct interest and service to transportation operating personnel.

Committee on Marine Transportation (*W. E. Jacobsen, Chairman; J. E. Jones, Vice-Chairman; W. N. Zippler, Secretary*). Since the preparation of the report of activities published in the August 1954 issue, this committee has held one meeting. As this issue goes to press, another is contemplated for October 5. In addition to revisions to keep up-to-date AIEE Standard No. 45, Recommended Practice for Electrical Installations on Shipboard, a complete new section on electronic communication and navigation equipment has been adopted to replace the three sections individually covering applications for radio communication, radio compass (direction finder), and echo sounding. This action has resulted from the increased use of electronic apparatus on shipboard, particularly the wartime developments of radar and loran. The new section will be included in the December 1954 issue of Standard No. 45.

At the Golden Jubilee meeting of the International Electrotechnical Commission (IEC) at Philadelphia, September 7–16, the Committee on Marine Transportation took an active part. This committee served as an advisory group on marine electrical practice to the U.S. National Committee of the IEC, and in support of the U. S. chief delegate on marine matters, who is also the chairman of AIEE's Marine Subcommittee on International Standardization.

The Marine Committee members were hosts to foreign delegates of Technical Committee No. 18 at a dinner party. This social affair was well attended and, it is believed, contributed to the success of the meeting by promoting better acquaintance and mutual understanding.

In the course of the meeting, IEC Technical Committee No. 18 approved the greater part of a code of recommendations for marine electrical practice which has been in preparation by that committee for several years. It is intended that this code will be the basis of standardization of marine practice throughout the world.

As a further step toward international standardization of marine electric practice, the Committee met last month with the chief engineer of Lloyd's Register of Shipping to consider differences in British and American practice, and to promote harmony.

Industry Division

Committee on General Industry Applications (*F. D. Snyder, Chairman; E. M. Hays, Vice-Chairman; B. T. Anderson, Secretary*). The accomplishments of the General Industry Applications Committee is measured chiefly by the work the various subcommittees have done. The Machine Tool, Rubber and Plastics, and the Textile Subcommittees have had their usual conferences, and the Materials Handling and the Paper and Pulp Subcommittees are again active in planning conferences. The newly formed Pacific Coast Subcommittee is now fully organized and has participated in the Summer General Meeting.

The use of the magnetic amplifier has been one of the most discussed topics for all of the industries covered by this Committee. Its capabilities have been thoroughly discussed

New Toll Dialing System Demonstrated

Leroy Langwell of the Southwestern Bell Telephone Company demonstrates to South Texas Section new toll dialing system being placed in operation in San Antonio, Tex. This system is capable of reaching 96 per cent of the telephones in the world. It will route calls automatically over circuits not in use and is capable of completing calls in 26 seconds. Mr. Langwell spoke to members and their wives recently at New Braunfels, Tex. Eighty-seven members from South Tex. were present for the induction of 1955 officers. New officers addressed the Section, telling of plans for the advancement of the engineering society and the electrical field. Coming meetings and events were outlined and a report on the convention at Los Angeles, Calif., was given by Mr. A. A. Mollenhauer, South Tex. Section Delegate

Ridgway Section Congratulates Winner

This picture was taken on the occasion of the award of the 1954 Elk County, Pa., Engineering Scholarship. Shown in foreground is Mr. J. H. Schneider (left), chairman of Ridgway Section's Vocational Guidance Committee, congratulating Mr. Edward H. Stoker of St. Mary's, Pennsylvania, who is the winner of the 1954 scholarship. In the background, left to right: Leo Simbeck, Section vice-chairman; W. P. VanVranken, chairman; R. F. Edwards, W. H. Austry, C. F. McGinnis, and Q. Graham, members of the Vocational Guidance Committee. Mr. Stoker, who is the second high school graduate to win the Elk County Scholarship, will attend the Pennsylvania State University this fall

North West District Executive Committee Meeting

The North West District Executive Committee meeting (held at Spokane, Washington, September 11, 1954) was the first committee meeting attended by Subsection representatives. Membership, student activities, and unity, were principal subjects discussed. North West District Vice-President John R. Walker presided. Members shown in the picture are: (left to right, kneeling) Walker; H. O. Bulmer, chairman, Vancouver Section; C. R. Kingsbury, vice-chairman, Membership Committee; R. E. Kistler, director; C. B. Brown, secretary, North West District. (Standing) R. J. Franzen, chairman, Tacoma Subsection; J. T. Turner, vice-chairman, Vancouver Section; L. R. Schumacher, chairman, Montana Section; H. C. Martindale, chairman, Spokane Section; D. L. Andrews, secretary, Boise Subsection; J. V. Fox, secretary, Spokane Section; W. E. Mathews, chairman, Wenatchee Subsection; C. B. Wagner, secretary, Richland Section; F. J. Maas, chairman, Portland Section; E. H. Olsen, chairman, Richland Section; J. V. Lamson, chairman, Seattle Section; R. R. Bracchi, vice-chairman, Portland Section; J. A. Davis, secretary, Utah Section; D. R. Allsop, chairman, Utah Section; L. R. Kersey, chairman, District Committee on Student Activities; A. W. Kessler, secretary, Seattle Section; T. E. Dickson, chairman, Vancouver Island Subsection; R. H. Osborne, chairman, Billings Subsection

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and the definite advantages of this system for regulating jobs of all kinds has been covered.

The Textile Subcommittee has been making great progress toward the standardization of suitable enclosures for electric equipment in textile mills. This same work is of interest to the Rubber and Plastics industries, as well as many industries having dusty and dirty environments, but is not specifically covered by any of the subcommittees.

Power Division

Committee on System Engineering (*A. P. Hayward, Chairman; R. T. Purdy, Vice Chairman; H. C. Otten, Secretary*). The System Planning Subcommittee sponsored two well-attended sessions on the use of high system voltages at the Summer and Pacific General Meeting in Los Angeles, Calif. Also at this meeting, the Committee participated in two joint sessions with the Committees on Computing Devices on The Application of Computers to Power System Operating Problems.

At the Fall General Meeting in Chicago, Ill., the System Operations Subcommittee sponsored two sessions covering the performance of station auxiliaries during periods of low system frequency.

At the Winter General Meeting in New York, the System Economics Subcommittee, the System Controls Subcommittee and the Power Generation Committee are jointly sponsoring a program covering the use of coal cost and line loss calculators with automatic load control.

The System Planning Subcommittee is actively engaged in preparing additional sessions covering several phases of the System Planning Function.

AIEE FELLOWS ELECTED..

Board of Directors Meeting, August 12, 1954

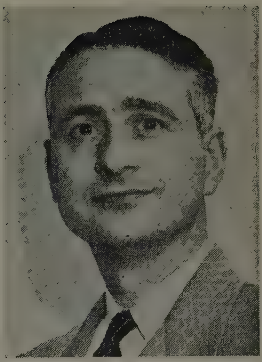
Orestes H. Caldwell (M'42), editor "Tele-Tech," Caldwell-Clements, Inc., New York, N. Y., has been transferred to the grade of Fellow in the AIEE "for his services to electronics engineering in the fields of publication and public service." Mr. Caldwell was born in Lexington, Ky., March 8, 1888. He obtained his B.S. in electrical engineering, 1908, electrical engineer degree, 1931, Doctor of Engineering, 1933, all from Purdue. His career for the past 47 years has included: assistant editor, *Electrical Review*, 1907–09; assistant editor, associate editor, *Electrical World*, 1910–17; various positions including editor, *Electrical Merchandising*, 1916–29; editor, *Radio Retailing*, 1925–35; commissioner, Federal Radio Commission, Washington, D. C., 1927–29; Chairman, U. S. State Department Delegations on International Radio, 1928–29; editor, *Electronics*, 1930–35; editor, *Radio Today*, 1935–44; editor, *Electrical Week*, 1939; radio commentator on weekly program of the National Broadcasting Company, "Radio Magic," 1939–42; editor, *Electronic Industries* and its successor in 1947, *Tele-Tech*, since 1942; editor, *Radio and Television Retailing* (name changed in 1953 to *Television Retailing*) 1944–53; member, National Television System Committee, which developed national compatible technical standards for color television, 1951–54. Dr. Caldwell is also the author of "Progress in Allied Fields to Radio," abstracted in *Proceedings of the I.R.E.* (Institute of Radio Engineers), March, 1936. In 1944 he was elected fellow of IRE and selected to make the acceptance speech for the group of twelve so honored. This speech was published in *Proceedings of the I.R.E.*, April 1945. In 1953 he was awarded a citation by the Radio Pioneers reading "for a brilliant career as an editor and publisher in the electrical, radio, and television fields over a period of more than 40 years." In 1953 he was also a member of a three-man committee for awarding grants from a fund of $100,000 established by Emerson Radio and Phonograph Company for furtherance of educational television.

Walter S. Gordon* (AM '27, M '35), consulting electrical engineer, Tacoma, Washington, has been transferred to the grade of Fellow in the AIEE "for contributions in the application of high intensity airfield lighting and in the adoption of higher distribution voltages in heavy western industries." Mr. Gordon was born in Seattle, Wash., November 17, 1904, graduated from the University

O. H. Caldwell

W. S. Gordon

L. M. Hull



A. J. Pansini

of Washington, 1926, with a B.S. degree in electrical engineering. After graduation, he became assistant engineer, Milwaukee Railroad Electrification Department. While with Milwaukee Railroad, he made studies of distribution system and locomotive performance leading toward higher electrical efficiency by the use of higher voltage and modified feeder arrangements. He outlined a plan for conversion of electric locomotives from 2-unit to 3-unit operation, which was later adopted. For a period of over ten years after graduation, Mr. Gordon continued to specialize in electrification of main line railroads through his affiliation with them or the consulting engineers or contractors performing the work. In August, 1928, he joined Jackson and Moreland as catenary designer for the Delaware Lackawanna and Western Railroad's 3-kv d-c suburban New Jersey electrification. In February, 1931, he made a 4-month tour of Western Europe where he inspected electrified railroads, electrical utilities, and manufacturing plants. It included 11 countries and every type of electrification then known in existence. Upon his return, an extensive article was published in *Electrical Engineering*, April, 1932. He then returned to railroad catenary design and construction. For more than two years he was affiliated with Vare Construction Company, Philadelphia, on field designs for the Pennsylvania Railroad electrification. Later he was placed in charge of erecting all catenary on the Baltimore-Washington Section of the Railroad, then supervising engineer for the company's contractors on the Paoli to Lancaster electrification. Between 1935 and 1941, he was superintendent of electrical construction, Philadelphia Navy Yard, and senior electrical engineer, McChord Field and Fort Lewis, in charge of design and construction of power and lighting systems for a variety of military facilities. From August 1942 to January 1946, he was Captain and then Major in the U.S. Army's Corps of Engineers. He was assigned to design and construction of air base and other military electrical installations in Alaska and the South Pacific. He was awarded the Citation for Legion of Merit by the U.S. Army, November 10, 1947. In 1945 he had established his own business as consulting electrical engineer, Tacoma, Wash. He has also held the following chairmanships: Special Code Committee to revise Tacoma's Electrical Code, 1947–48; Tacoma Chamber of Commerce, Industrial Bureau's Power Committee, 1949–50; Tacoma Chamber of Commerce, Industrial Bureau, 1951; Tacoma Chamber of Commerce State Development Committee, 1953; Washington State Power Commission, 1953–55. He was also director of the Tacoma Chamber of Commerce 1952–53; member Energy Resources Subcommittee, Washington State Industrial Development Committee; president, Tacoma Engineers Club, 1952; member AIEE Committee on Industrial Power Systems.

Lewis M. Hull (M '27), board chairman Aircraft Radio Corporation, Boonton, N. J., has been transferred to the grade of Fellow in the AIEE "for his many contributions to radio communication and to the utilization of vacuum tubes therein." He was born in Great Bend, Kan, February 27, 1898. He attended the University of Kansas where he was graduated with the A.B. degree in 1917, and received his A.M. in 1918. In 1922 he received his Ph.D. from Harvard University. He joined the Bureau of Standards in 1917 as radio aide, and in 1918 was civilian radio instructor for the Reserve Officers Training Corps. He was assistant and associate physicist, U. S. Bureau of Standards, 1918–20; consulting physicist, 1920–22; from 1922–26 director of research for Radio Frequency Laboratories, Inc. vice-president and director, 1926–29. From 1927–28 he was special consultant to the General Radio Company. From 1929–30 he was vice-president and director of Aircraft Radio Corporation; from 1930–51, president and director of Aircraft Radio Corporation, and was treasurer from 1946–52. During the time he was president of Aircraft Radio Corporation he was awarded some twenty patents for inventions made dealing broadly with methods, materials and apparatus for radio transmission and reception. He was also a pioneer investigator of the principles of wave-propagation to and from aircraft. He became chairman of the board of directors of the corporation in 1952. Dr. Hull also acted as Expert Consultant to the Secretary of War during the years 1943–45. He has been prominent in municipal matters and has been a trustee of the Riverside Hospital. A past-president of the Institute of Radio Engineers, Dr. Hull has served on many committees important to the engineering profession. Dr. Hull is a member of Phi Beta Kappa, Sigma Xi, and Pi Epsilon. Besides his many engineering society memberships, he is a trustee of St. John's School, Mountain Lakes, N. J., and belongs to the following clubs: Lotos (New York), Orange Lawn Tennis, and University (Washington, D. C.).

Anthony J. Pansini (M '39), manager, Meters and Distribution Engineering Department, Long Island Lighting Company, Mineola, N. Y. has been transferred to the grade of Fellow in the AIEE "for contributions to the development of transmission and distribution systems capable of serving adequately a load of exceptionally rapid growth." Mr. Pansini was born November 19, 1909. He is a graduate of Cooper Union Institute of Technology with a bachelor's degree in electrical engineering, 1931. He was awarded the electrical engineer degree in 1938. He entered industry as a junior draftsman in 1925 for F. R. Ley, Consulting Engineer, New York, N. Y. The following year he became a tester (Test work was during installation of 132 kv oil-filled cables and also of new and salvaged cables.) for United Electric Light and Power Company, New York, N. Y. From 1928–32 he was engineering assistant for United Electric Light and Power. Then with the New York Edison Company he served in the following positions: engineering assistant, 1932–33; junior engineer, 1933. From 1933–36 he was in charge of load studies and voltage regulation work for the d-c and a-c distribution systems in the boroughs of Manhattan and Bronx, New York, N. Y. From 1936–38 he was with the General Engineering Division, Electrical Engineering Department, of Consolidated Edison Company, New York. From 1938–41 he was assistant engineer, Outside Plant Bureau, Electrical Engineering Department, of Consolidated Edison. In 1941 he joined the Operating Department of this same company where he has been successively: senior electrical engineer, staff engineer, materials and methods engineer. He then became engineering co-ordinator of construction, reporting directly to the operating vice-president; assistant to the electric transmission and distribution manager; manager, meters and distribution engineering. A summary of Mr. Pansini's achievements at the Long Island Lighting include the following: reorganization of distribution section into a more efficient operation consisting of distribution planning engineering, mapping and estimating, and distribution design engineering; forming of the test department; being instrumental in developing the 13.2 kv distribution system on Long Island which enabled the system to meet the large load growth after World War II; initiating secondary network system in high density areas; furthering the use of capacitors on the system resulting in a net gain of almost five million dollars when figuring the equivalent investment in generating capacity which would have been necessary to do the same job.

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* Mr. Gordon's transfer to grade of Fellow was approved by the Board of Directors on June 24, 1954.

AIEE PERSONALITIES.....

H. A. Winne (AM '16, F '45, Member for Life), retired General Electric Company vice-president at Schenectady, N. Y., will be awarded the 1955 John Fritz Medal, "for service to his country in war and peace through his distinguished leadership in the electrical industry." The award will be presented during the Institute's General Winter Meeting in New York City. This medal is awarded annually by a board composed of four representatives of each of four national engineering societies: the AIEE, the American Society of Mechanical Engineers, the American Institute of Mining and Metallurgical Engineers, and the American Society of Civil Engineers. It was established by professional associates and friends of John Fritz on August 21, 1902, his eightieth birthday, to perpetuate the memory of his achievements in industrial progress. Mr. Winne, a director of the American Gas and Electric Company, New York, N. Y., was born October 27, 1888, at Cherry Valley, N. Y. He joined General Electric in 1910, the same year he graduated from Syracuse University with the degree of electrical engineer. In 1911 he became head of the large motor, generator, and synchronous converter test, and about a year later became assistant night foreman of the testing department. He was promoted to the power and mining engineering department five years later. Mr. Winne was transferred to the steel mill section of the industrial engineering department and became head of that organization eight years later. In October, 1941, he was elected vice-president and was put in charge of design engineering for the apparatus department. Four years later he was appointed vice-president in charge of engineering policy for the company. He has served with various governmental advisory groups. Mr. Winne has also received the National Society of Professional Engineers' Award, the 1953 James H. McGraw Award, and honorary doctorate degrees from: Syracuse University, Rensselaer Polytechnic Institute, Rhode Island University, and Newark College of Engineering. He is a fellow of the American Society of Mechanical Engineers and a member of the National Society of Professional Engineers, New York State Society of Professional Engineers, and the American Society for Engineering Education. He has served on the following AIEE committees: Applications to Iron and Steel Production (1930–38); Electric Welding (1934–40); and Edison Medal (1947–52).

H. A. Winne

Jesse Edward Hobson (AM '36, F '48), director of Stanford Research Institute, has succeeded to the national presidency of Eta Kappa Nu Association, electrical engineering honor society. Dr. Hobson presided at Eta Kappa Nu's convention at the time of its Golden Anniversary observance at the University of Illinois, Urbana, on October 15 and 16. He was born May 2, 1911, at Marshall, Indiana, and was graduated from Purdue University with a B.S. in electrical engineering in 1932, an M.S. in electrical engineering, 1933, and a Ph.D. from California Institute of Technology in 1935. He was assistant professor of mathematics, Earlham College, Richmond, Ind., 1935–36; instructor of electrical engineering, Armour Institute of Technology, Chicago, Ill., 1936–37; central station engineer, Westinghouse Electric Corp., East Pittsburgh, Pa., 1937–41; director, Department of Electrical Engineering, Illinois Institute of Technology, Chicago, Ill., 1941–44; director Armour Research Foundation, 1944. His memberships, other than AIEE and Eta Kappa Nu, include: Triangle, Sigma Xi, Sigma Delta Chi, Tau Beta Pi, Purdue Club of Pittsburgh, and the Masonic Order. His AIEE activities have been with the following committees: Basic Sciences (1941–45); Electrochemistry and Electrometallurgy (1943–45); Education (1944–45); Power Transmission and Distribution (1944–47); Standards (January-August 1945, 1949–50); Communication (1946–47); Registration of Engineers (1946–49, [Chairman 1947–49] 1950–51); Chemical, Electrochemical, and Electrothermal Applications (1946, 1948–53); Research (1947–49); Electronics (1947–54); Professional Group Coordinating (1947–49); National Bureau of Engineering Registration, Advisory Board (1947–49); Instruments and Measurements (1949–53); Liaison Representative on Standards (1952–54); and Science and Electronics Division (1953–54).

Dr. E. E. Charlton (AM '45), consultant in nucleonics and radiation at the General Electric Research Laboratory at Schenectady, N. Y., has been chosen as the Mehl Honor Lecturer for the annual convention of the Society for Nondestructive Testing, to be held in Chicago, November 1–4 at the Morrison Hotel. He was born in Meriden, Iowa, September 17, 1890, and was graduated from Grinell College, Iowa, in 1913. In 1918, he received his Ph.D. in chemistry from the University of Illinois. During 1918 and 1919 he served as lieutenant in the Chemical Warfare Service, and later in 1919 as instructor in chemistry at the University of Illinois. Still later that year, he joined E. I. duPont de Nemours and Company to do research in dye chemistry. He became a research engineer in the Research Laboratory of the General Electric Company, Schenectady, N. Y., in 1920. In 1928, he was placed in charge of the X-ray Section. While serving as manager of the X-ray Section of the research laboratory's Electron Physics Research Department, he was directly responsible for construction of GE's 100,000,000-volt electron accelerator. He has served on the following AIEE committees: Therapeutics (1946–49), (he was chairman of this committee in 1947, and 1948–January '49); Communication and Science Coordination (1947–49); Standards (1947–49); Technical Program (1947–49).

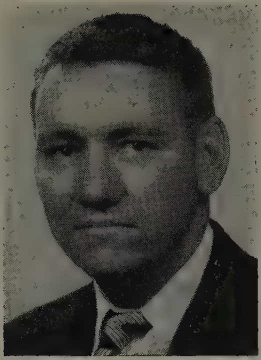
J. E. Hobson

C. H. Ducote (AM '33) has become export manager for Trailmobile, Inc. of Cincinnati, Ohio. He will be located at the company's New York office at 52 Vanderbilt Avenue. A native of Marksville, La., Mr. Ducote holds a B.S. degree from the Massachusetts Institute of Technology. He has had wide experience in the export field and has worked in many foreign countries. For 14 years, he was U. S. trade commissioner and commercial attache in Buenos Aires, Budapest, Havana, Brussels, and Paris, advising American firms interested in establishing foreign affiliates, undertaking market development and related activities. He was connected with the Industry Division of the Economic Cooperation Administration in Paris on the development of measures to increase industrial productivity in Marshall Plan countries, and has investigated foreign markets for the establishment of manufacturing affiliates in the Netherlands, Belgium, France, Greece, and Turkey. He is the author of a number of industrial and market surveys, trade promotion reports, and technical papers.

Emmett R. Shute (M '17, F '45, Member for Life) retired as vice-president of the Western Union Telegraph Company, August 31. He now joins the Serial Federal Building and Loan Association as president, New York, N. Y. Mr. Shute received his B.S. degree from Purdue University and joined Western Union as assistant to the traffic engineer, New York, in 1912. He pioneered many of the company's outstanding technical advances. He was early to recognize the role of the engineer as a business executive, and four of the men he trained are now vice-presidents of Western Union. Mr. Shute's first Western Union assignment was to test early models of the electromagnetic printer, which now provides direct wire connections with the national telegraphic system for 22,000 companies. He conducted the first trial of the multiplex printing telegraph system, which permitted the transmission of eight telegrams simultaneously over one wire. He also created a model time and cost-keeping system which is still in use. He was responsible for the establishment of the Water Mill (N. Y.) Electronics Laboratory of the telegraph company in 1920. During World War II, Mr. Shute was chief liaison officer between Western Union and the Armed Services with the rank of Lieutenant Colonel and was Chairman of the Telegraph Committee of the Board of War Communications. He was awarded a Chief Signal Officer's Certificate of Appreciation. He organized Western Union's Committee on Technical Publications. This had as a principal objective the encouragement of young engineers in technical writing. He was active in the formation of the Radio Club of America; is a senior member of the Institute of Radio Engineers, and vice-president of the New York Chapter, Armed Forces Communications Association. He has served as president and director of a number of Western Union's subsidiary companies, and director of Ramp Building Corporation. He served on AIEE's Communication Committee (1931 to 1943), and was a foremost proponent of AIEE's Technical Division.

Nicolas N. Smeloff (AM'18, M'54), system planning engineer for Pennsylvania Power and Light Company, Allentown, Pa., retired as of September 1, 1954. Mr. Smeloff is a veteran of more than 33 years service with the company. He plans to engage as a consultant in electric power systems, formulating system planning and development programs, based on growth, economic factors, and studies of power system components: generation transmission, distribution and service buildings and yards. Born in Russia, Mr. Smeloff was graduated in electrical engineering from the Polytechnical Institute, St. Petersburg. During World War I, he came to America as an ammunition engineer for the Russian Department of War. He joined the General Electric Company in 1918, working for three and one-half years in the test and engineering departments at Pittsfield, Mass., and Schenectady, N. Y. In 1921, he joined Pennsylvania Power and Light Company and worked in the transmission, construction, and operating departments in Hazleton and Allentown, Pa. In 1929 he organized the company's system planning department and has since directed all system planning activities for the utility in its 10,000 square mile service area in Central Eastern Pennsylvania.

Joseph W. Rittenhouse (AM'40, M'48), assistant professor of electrical engineering, School of Mines and Metallurgy, University of Missouri, Rolla, has been appointed technical director of Hi-Voltage Equipment Company. Mr. Rittenhouse graduated from Purdue University in 1939 with a BSEE degree. Later he obtained his MSEE. After his graduation in 1939, he joined the James R. Kearney Corporation in St. Louis, Missouri, where he spent five years in engineering and administration, the last three years as New England district engineer. In 1943, he entered the U. S. Army Signal Corps and he now holds the rank of Major in the U. S. Army Reserve. After leaving the Army, he joined the University of Missouri at Rolla, where he was associate professor of electrical engineering. Quite active in engineering circles, Mr. Rittenhouse is a member of AIEE, ASEE, and Sigma Xi. Also, he is a member of Eta Kappa Nu, Tau Beta Pi, National Society of Professional Engineers, Missouri Society of Professional Engineers, and the Institute of Radio Engineers. His AIEE activity includes: member Committee on Student Branches 1953–54; chairman Seventh District Committee on Student Activities 1953; member St. Louis Section Membership Committee 1951–53; and member Seventh District Executive Committee 1953. Mr. Rittenhouse is an accomplished speaker on technical subjects; he has prepared several articles on electric power transmission for the technical press. Just recently, in conjunction with Doctor John Zaborszky, he wrote an authoritative book entitled "Electric Power Transmission."


J. W. Rittenhouse

Marvin Camras

Marvin Camras (AM '41, M '47), senior physicist at Armour Research Foundation of the Illinois Institute of Technology, Chicago, Ill., and inventor of modern magnetic recording, will receive the John Scott award for scientific achievement—the same honor bestowed on such notables as Thomas Edison, Orville Wright, and Madame Curie. The award, which consists of $1,000 cash, a copper medal, and a scroll, will be presented by the City of Philadelphia, trustee. Mr. Camras will receive the award for his discoveries and subsequent improvements in magnetic recording. The date of presentation has not been announced. Camras' pioneer work in magnetic stereophonic sound (3-dimensional sound) contributed to the development of Cinerama and Cinemascope. In 1940, he joined the staff of Armour Research Foundation to perfect the recorder and perform research in remote control, high speed photography, magnetostriction, oscillators, and static electricity. As a result of his investigations, the Foundation owns or controls more than 250 patents registered in many countries. Camras is a member of the Chicago Physics Club, Chicago Acoustics and Audio Group, American Association for the Advancement of Science, Institute of Electrical Engineers, Society of Motion Picture and Television Engineers, Eta Kappa Nu, Tau Beta Pi, and Sigma Xi. He is a fellow in the Institute of Radio Engineers and the Acoustical Society of America.

E. F. Carter (AM'24, M'47), vice-president and technical director, Sylvania Electric Products Inc., New York, N. Y., has been appointed manager of research operations of Stanford (Calif.) Research Institute. He will retain an association with Sylvania, assisting in contacts with the Department of Defense and consulting on major research and development contracts. A native Texan, Mr. Carter was graduated with a degree in electrical engineering from Rice Institute in 1922. Shortly thereafter he joined the General Electric Company as a radio development engineer. One of his earliest assignments with General Electric was the development of the three early high-power transmitters, *WGT* in Schenectady, N. Y.; *KGO* in Oakland, Calif.; and *KOA* in Denver, Colo. In 1929 he became director of the engineering division of United Research Corporation, New York. He joined Sylvania in 1932 as a consulting engineer, later becoming radio division engineer at Emporium, Pa., then assistant chief engineer. In 1941 he was appointed to head Sylvania's new industrial relations department and subsequently was elected a vice-president. In 1946 he became vice-president in charge of engineering and was appointed vice-president and technical director in 1953. Mr. Carter is a member of Tau Beta Pi, the Illuminating Engineering Society, and the Institute of Radio Engineers.

H. E. Boatright (AM '12, M '42, Member for Life), power superintendent of the Guanajuato Power and Electric Company, Guanajuato, Mexico, retired June 30, 1954. Mr. Boatright, a native of Missouri, is a graduate of Colorado College, with a degree of bachelor of science in electrical engineering. He joined Guanajuato Power and Electric Company in 1908. His residence is now 844 East Monument Street, Colorado Springs, Colorado.

M. N. Halberg (AM'29, F'51), industrial engineering section, General Electric Company, Schenectady, N. Y., has been named application engineer of the large motor and generator department. A graduate of the University of California with a bachelor of science degree, Mr. Halberg joined General Electric after graduation in 1926 and was assigned to the test course. Later he completed the advanced engineering course and then specialized in the application of motors and control for compressor drives and engine-driven generators in the Industrial Engineering Division. From 1936 to 1941 he was assigned to the Motor Division. During World War II he was a specialist on application problems of early types of aircraft jet engines. After the war he was assigned to the industrial engineering section, serving as application engineer for all industrial power equipment. Mr. Halberg is a member of Tau Beta Pi, Eta Kappa Nu, and Sigma Xi.

M. N. Waterman (AM'49), assistant manager, commercial engineering department, Lamp Division, Westinghouse Electric Corporation, Bloomfield, N. J., has been elected vice-president of the Illuminating Engineering Society. Mr. Waterman was graduated from Massachusetts Institute of Technology in 1924 with an electrical engineering degree. In 1926 he joined the lighting sales department of the Central Hudson Gas and Electric Corporation, Poughkeepsie, N. Y., and later became supervisor of lighting sales. In 1942 he joined the War Production Board in Washington, D. C., as assistant director of the building materials division. He spent three months in England and Germany in 1945 as deputy director of the building construction team of the Technical Intelligence Committee. Following World War II he became a member of the executive staff of the Electrical Testing Laboratories, Inc., and in 1948 joined the Westinghouse Lamp Division as staff assistant to the manager of commercial engineering. He was made assistant manager in 1952. Mr. Waterman has served on the AIEE Committee on the Production and Application of Light (1950–54).

M. S. Angier (AM'39), manager, electrical utility section, Westinghouse Electric Corporation, New York, N. Y., has been appointed product manager of heat pumps for the Air Conditioning Division. Mr. Angier joined Westinghouse in 1924 following graduation from the University of Illinois.

A. L. Penniman, Jr. (AM'15, F'43), vice-president, Consolidated Gas Electric Light and Power Company of Baltimore, Md., has been elected an honorary member of the American Society of Mechanical Engineers. Mr. Penniman was born in Bel Air, Md., in 1892, and was educated at the Baltimore Polytechnic Institute. Mr. Penniman has spent his entire professional career with the Consolidated Gas Electric Light and Power Company of Baltimore, which he joined in 1911 as a draftsman. Within three years he was promoted to superintendent of steam-electric generating stations in complete charge of plant operations and maintenance programs. In 1937 he became general superintendent and was elected vice-president in 1950. He is a member of the American Association for the Advancement of Science, the Maryland Academy of Sciences, National Society of Professional Engineers, the American Society of Naval Engineers, the Naval Institute, and the American Ordnance Association. He has served on the following AIEE committees: Power Generation (1922–24, 1932–34); and Membership (1924–25).

Harold Goldberg (AM'35, M'44), chief, Guided Missile Fuzing Laboratory, Diamond Ordnance Fuze Laboratory, Washington, D. C., has been named director of the Emerson Research Laboratories, Washington, D. C. Dr. Goldberg is a graduate of the University of Wisconsin. Prior to joining the National Bureau of Standards, Ordnance Electronics Division, predecessor of Diamond Ordnance Fuze Laboratory, he held positions as principal research engineer, Bendix Aviation Corporation, and senior research engineer, Stromberg-Carlson Company. Dr. Goldberg is a senior member of the Institute of Radio Engineers and a member of the American Physical Society, Tau Beta Pi, Eta Kappa Nu, and Sigma Xi.

H. A. Glover (AM'39), southeastern regional manager, I-T-E Circuit Breaker Company, Atlanta, Ga., has been appointed sales manager of the R&IE Equipment Division of the company. A graduate of Carnegie Institute of Technology in 1932, Mr. Glover had early experience with West Penn Power Company and Carnegie Steel Corporation. He was formerly associated with I-T-E from 1938 to 1946, with 3 years in the U. S. Navy, 1942–45. Mr. Glover served as sales manager of S&C Electric and Electrical Engineers Equipment Company until June 1953 when he returned to I-T-E as southeastern regional manager.

Louis Meyerhoff (M'39), associate research director, General Cable Corporation, Bayonne, N. J., has been named director of research. He has been associated with General Cable for 26 years, all but one year of which have been spent in the research department. Mr. Meyerhoff holds the degree of bachelor of science in electrical engineering from Johns Hopkins University and the bachelor of laws degree from the University of Maryland.

E. J. Kallevang (AM'14), chief engineer Wisconsin Power and Light Company, Madison, has been elected vice-president in charge of engineering, system operation, and maintenance. A native of Decorah, Iowa, Mr. Kallevang was graduated from Highland Park College with a bachelor of science degree in electrical engineering. He joined the Southern Wisconsin Power Company, a predecessor of Wisconsin Power and Light, in 1915, as line superintendent and became chief engineer 2 years later. He is a past president of the Wisconsin Society of Professional Engineers.

C. S. Walker (AM'40, M'49), associate professor, Texas Agricultural and Mechanical College, College Station, has joined the staff of the Oak Ridge (Tenn.) National Laboratory.

W. E. Powell (AM'40), control engineer, Jones and Laughlin Steel Corporation, Pittsburgh, Pa., has been named president of Control Products Company, Inc., Oakdale, Pa.

J. A. Peterson (AM'50), electrical engineering faculty, Gonzaga University, Spokane, Wash., has been appointed an instructor in electrical engineering at California State Polytechnic College, San Luis Obispo. Mr. Peterson has undergraduate and graduate degrees in electrical engineering from the University of Idaho. He is a former test engineer for General Electric at Schenectady.

R. M. Darrin (AM'28, M'34), commercial vice-president in charge of customer relations in the New York and New England areas, General Electric Company, New York, N. Y., has retired following 35 years of service with the company. A native of Corning, N. Y., Mr. Darrin attended Amherst College, served 2 years as a first lieutenant in World War I, and joined General Electric at Pittsfield, Mass., in 1919. Following executive assignments at district offices at Buffalo and Syracuse, N. Y., he was transferred to New York City in 1945 as district manager of transportation for the company's Apparatus Division. In 1947 he was named manager of customer relations for the Central Stations Division at Schenectady, N. Y., in 1949 a commercial vice-president of the New England district with headquarters at Boston, Mass., and in 1951 he assumed his latest position. He is a member of the Engineers Club of New York City and the American Society of Mechanical Engineers, and a director of the Electric Institute of Boston.

G. V. Patterson (AM '47), executive assistant, Ohio Power Company, Canton, has been appointed assistant general manager. Mr. Patterson is a graduate of Ohio State University. He started with Ohio Power in 1935 as a meter installer. He served as power engineer in Newark, Crooksville, Lancaster, and Canton before he was named assistant manger of the commercial-industrial department in 1941. He was made administrative assistant in 1950 and executive assistant in 1952.

C. L. Matthews (AM'09, F'27, Member for Life), president, W. N. Matthews Corporation, St. Louis, Mo., has become a vice-president and director of the A. B. Chance Company, St. Louis, following the sale of the Matthews Corporation to Chance.

B. O. Austin (M'43, F'51), manager, control section, aviation engineering department, Westinghouse Electric Corporation, Lima, Ohio, has been awarded the Westinghouse Order of Merit for "his consistent and resourceful leadership in developing engineering pre-eminence for Westinghouse in the control field of the aircraft industry and for his outstanding ability to train young engineers in the highest Westinghouse tradition." Mr. Austin joined Westinghouse in 1914 shortly after graduating from North Carolina State College with a bachelor of science degree in electrical engineering. In 1922 he also received the degree of electrical engineer from the same institution. From that time until 1942, except for a short period during World War I, he was associated with the company at East Pittsburgh, Pa. Mr. Austin is serving on the AIEE Committee on Air Transportation (1951–54).

H. H. Sheldon (M'43), dean of the Division of Research and Industry, University of Miami, Fla., has been appointed consultant to the Organization for European Economic Co-operation, Paris, France.

J. V. Manning (AM'36), divisional manager, Micro Switch Division, Minneapolis-Honeywell Regulator Company, Chicago, Ill., has been appointed general manager of the Marine Equipment Division of the company, Seattle, Wash.

R. W. Atkinson (AM'09, F'28), Member for Life), director of research, General Cable corporation, Bayonne, N. J., has resigned, but will continue as a consultant for the company and also as a consulting engineer. Mr. Atkinson is a graduate of Iowa State College, holding degrees of bachelor of science in electrical engineering and electrical engineer. He was granted the Marston Medal in 1951. Mr. Atkinson was a member of the nonparticipating group of scientific and engineering observers at the Bikini atomic bomb tests in 1946. He is a member of Tau Beta Pi and a fellow of the American Association for the Advancement of Science. He has served on the following AIEE committees: Transmission and Distribution (1919–30); Research (1933–41); Standards (1934–54); and Board of Examiners (1945–54).

OBITUARIES

Howard Edward Dyche (AM'09, M'17, F'42, Member for Life), retired head of the University of Pittsburgh's Electrical Engineering Department, died April 11, 1954. The Institute regrets the tardiness of this notice. Mr. Dyche was born in Spring Valley, Ohio, January 19, 1884. He received his master's degree in electrical engineering from The Ohio State University in 1906. From 1905 to 1906 he was student assistant in the Department of Physics at the University. In April of 1906 he was elected to Sigma Xi and in July entered an apprenticeship course of Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa. The following year he transferred to the Railway Division of the Engineering Department as engineer on d-c railway, mining and vehicle motors. He was intimately connected with and had charge of a large portion of the experimental and development work on the interpole d-c railway motor. From 1908–09 he had responsibility for mining locomotive application. Mr. Dyche left Westinghouse to enter the automobile business in 1910 and was president of the Pennsylvania Automobile Company. He first became associated with the University of Pittsburgh in 1911 as instructor in engineering mathematics. He was given the additional duties of instructor in physics in March 1912 and in October of that year transferred to the Department of Electrical Engineering as instructor. He was promoted to assistant professor of electrical engineering two years later. His next promotion was to associate professor of electrical engineering in June, 1917. In October he was made acting head of the Electrical Engineering Department. He also became consulting electrical engineer for Pittsburgh Testing Laboratory, Pittsburgh Metallurgical Company, and Morris Knowles Company that same year. In 1927 he inaugurated a plan of graduate study for those working full-time in local industries. (Upon his retirement last year he also held the title of director of graduate work in industry.) This idea has become a permanent part of the curriculum of many universities. Professor Dyche was invited to Washington in 1936 for the Third World Power Conference to discuss national power economy. In 1931 he was granted a patent on an oscillograph camera. During 1950 he was acting dean of the Schools of Engineering and Mines. His name has appeared in "Who's Who in America," "Who's Who in Engineering," and "American Men of Science." His memberhips included: AIEE, Society for Promotion of Engineering Education, the University Club, Sigma Xi, Sigma Tau. He was also a charter member of the Beta-Delta Chapter of Eta Kappa Nu and was its first faculty advisor. He served on AIEE's Education Committee (1929 to 1933).

Winthrop Keith Howe (AM'01, Member for Life), formerly vice-president in charge of engineering of the General Railway Signal Company, Rochester, N. Y., died unexpectedly at his home, August 20, 1954. Mr. Howe was born at Clifton, Illinois, in 1868. He graduated from Purdue University in 1889 as a mechanical engineer. After graduate work in electrical engineering, he entered industry with the Western Electric Company, Chicago. In 1900 he joined the Taylor Signal Company of Buffalo, New York, and later became chief engineer of that company. In 1904 the Taylor Signal Company merged with the Pneumatic Signal Company of Rochester, New York, to form the present General Railway Signal Company. At that time, he was appointed chief engineer of the new company, the position he held until he became vice-president in charge of engineering in 1943. During his career with G.R.S, Mr. Howe was in charge of research, design, and engineering work, including electric interlocking, automatic block signaling, automatic train control, cab signaling and speed control, centralized traffic control, and car retarder systems for freight classification. Among other projects, he engineered the G.R.S installations in the Hudson tunnel, on the Centre Street loop of the New York Municipal Railway, and for the New York Central's Electric Zone. After his retirement in 1945, he continued to serve in an advisory capacity. Mr. Howe was a member of the Signal Section of the Association of American Railroads, Society of Automotive Engineers, and the Institution of Railway Signal Engineers (British), as well as AIEE. He served on AIEE's Transportation Committee from 1925 to 1930.

Robert Bridge Bonney (AM '03, M '18, F '37, Member for Life), retired educational director and employment supervisor of the Mountain States Telephone and Telegraph Company, Denver, Colorado, died August 21, 1954. He was a past Vice President of AIEE. Mr. Bonney had been retired from the Mountain States Telephone and Telegraph Company since October 1, 1942, after more than 44 years of service. He was born in Dedham, Mass., on September 25, 1877, and was graduated from Partridge Academy, Duxbury, Mass. He went to Denver in 1895 and engaged in telephone construction, equipment maintenance, engineering, and operations work from August 1, 1895, until his retirement, except during a period from October 1907 to April 1910. During that time he was engaged in consulting work and in the supervision, construction, and operation of the private telephone system of the Central Colorado Power Company. He had experience in all departments of the telephone business, holding supervisory positions of: wire chief, superintendent of maintenance, assistant equipment engineer; and at the time of his retirement was educational director and employment supervisor of the Mountain States Telephone and Telegraph Company. Mr. Bonney was the author of a series of texts on telephone plant and commercial practices for use in training telephone company employees. He was very active in organizing the Denver Section of the AIEE, which he served as secretary-treasurer from 1915 to 1929, as vice-chairman 1929–30, and as chairman 1930–31. He was a charter member of the Denver Section, and was a vice-president of District 6 of the AIEE, from 1933 to 1935. Mr. Bonney was also active in organizing the Colorado Engineering Council, of which he was a past president. On December 16, 1944, the Colorado Engineering Council presented Mr. Bonney with its Gold Medal Honor Award for distinguished and meritorious service to the engineering profession, and cited as an example of this service his outstanding work in co-ordinating engineering education. He was awarded the War Department Certificate for marked service to the United States as a member of the Committee on Education and Special Training, War Plans Division, General Staff 1917–1918. He was a past master of Union Lodge No. 7, and was a Royal Arch Mason and Knight Templar. Mr. Bonney's AIEE Committee activities were: Membership (1925–28); Student Branches (1933–36); Education (1933–35).

Ernest Adolphe Bureau (AM '18, M '33), professor emeritus and former head of the Department of Electrical Engineering of the University of Kentucky, died July 13, 1954. He was born at La Chapelle Aux Naux, France, and came to the U. S. when he was four years old. His family settled in Kansas. He was a graduate of Ottawa University, from which he obtained the Bachelor of Philosophy degree. He later attended Purdue University and received the bachelor's degree in electrical engineering and the electrical engineer degree in 1916. At the California Institute of Technology he did advanced graduate work from 1940 to 1941. The following year he was appointed head of the Department of Electrical Engineering at the University of Kentucky, where he had served since 1918. He retired in 1952 because of ill health. Professor Bureau was a member of the AIEE, National Society of Professional Engineers, Kentucky Society of Professional Engineers, Indiana Alpha, Tau Beta Pi, Eta Kappa Nu, Sigma Xi, and an active member of the Central Christian Church of Lexington, Kentucky.

Ashton Burton Cooper (M '16, F '33, Member for Life), president of Ferranti Electric, Ltd., Toronto, Ont., Canada, died September 15, 1954. He was a past Vice-President of the Institute and was an extremely interested and active member. Mr. Cooper was born in Bloomfield, Ontario, December 31, 1883, and obtained his B.S. degree in electrical engineering at Tufts College, June, 1903. He entered industry with the General Electric Company that same month, in the testing department. From 1905–07 he was inspector for the Rio de Janeiro Tramway Company, located at Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa. He was installation engineer at Rio das Lages, Brazil, 1907–09. He was also with General Electric Company's Transformer Commercial Department, Schenectady, N. Y., 1909–13; in charge of the Transformer Department for Canadian General Electric Company, Toronto, 1913–22; general manager, Ferranti Electric, Ltd., Toronto, 1922–28; vice-president and general manager for Ferranti, 1928–33. He was a past-president of the Engineers' Club of Toronto and of the Association of Professional Engineers of Ontario, a member of the Engineering Institute of Canada, and an associate member of the Institution of Electrical Engineers of Great Britain. He joined AIEE as a member in 1916, taking an active interest in the Toronto Section, of which he was chairman from 1919 to 1920. He was Vice-President for District No. 10 from 1927 to 1929, and served on the following committees: Lighting and Illumination (1920–23); Membership, (1926–27, 1936–37); Electrical Machinery (1928–29, 1933–36); Standards (1931–36); liaison representative on Standards Committee (1951–52).

MEMBERSHIP • • •

Recommended for Transfer

The Board of Examiners at its meeting of September 16, 1954, recommended the following members for transfer to the grade of membership indicated. Any objections to these transfers should be filed at once with the secretary of the Institute. A statement of valid reasons for such objections must be furnished and will be treated as confidential.

To Grade of Member

Aaltonen, L. O. T., engineer, Puget Sound Power & Light Co., Seattle, Wash.
Ager, R. P., distribution engineer, Pennsylvania Electric Co., Erie, Pa.
Anderson, K. O., sales & application engineer, General Electric Co., Erie, Pa.
Andrias, J., senior research engineer, Given Manufacturing Co., Bethesda, Md.
Anest, N., district adminstrative asst., Tennessee Valley Authority, Knoxville, Tenn.
Angst, G., development engineer, General Electric Co., West Lynn, Mass.
Antel, J. S., Jr., electrical engineer, Naval Ordnance Laboratory, Silver Spring, Md.
Arters, E. T., project engineer, Westinghouse Electric Corp., East Pittsburgh, Pa.
Ashby, C. W., field engineer, Line Material Co., Birmingham, Ala.
Berri, T. L., system protection engineer, Public Service Co. of Colorado, Denver, Colo.
Blaye, R. S., asst. planning engineer, Southern California Edison Co., Los Angeles, Calif.
Boyd, Richard H., supervisory telephone service, Pennsylvania R.R., New York, N. Y.
Boyd, Robert H., senior engineer, Southwestern Bell Telephone Co., Little Rock, Ark.
Brandenburg, G. F., electrical engineer, U. S. Govt., Camp Detrick, Md.
Brenner, M., assoc. technical service engineer, Burndy Engineering Co., Inc., Norwalk, Conn.
Brown, H. K., electric design engineer, The Dow Chemical Co., Freeport, Tex.
Brown, P. G., application engineer, General Electric Co., Schenectady, N. Y.
Brown, R. J., supervisor, Bonneville Power Administration, Portland, Ore.
Bryant, W. C., research & development engineer, Lockheed Aircraft Corp., Burbank, Calif.
Caldwell, S. Y., Jr., senior engineer, Alabama Power Co., Birmingham, Ala.
Carpenter, N. G., industrial electrical engineer, Gulf States Utilities Co., Lake Charles, La.
Carrick, D. S., production engineer, Sandia Corp., Albuquerque, New Mex.
Cervantes, I., chief engineer, Telefonos de Mexico, S. A., Mexico, D. F.
Christensen, E. F., engineering supervisor, General Electric Co., Pittsfield, Mass.
Cline, E. W., distribution engineer, Commonwealth Edison Co., Chicago, Ill.
Corcoran, C. S., electrical engineer, National Advisory Comm. for Aeronautics, Cleveland, Ohio.
Cottom, M. C., electrical design engineer, Black & Veatch, Kansas City, Mo.
Cumming, M. L., system operations engineer, Light Dept., City of Tacoma, Wash.
Curtin, J. R., relay planning unit chief, Bonneville Power Administration, Portland, Ore.
Darrow, K. G., manager, outdoor power circuit breaker eng'g., General Electric Co., Philadelphia, Pa.
Davis, R. T., electrical engineer, Corbett Industries, Inc., Wilmington, N. C.
Decker, J. E., electrical engineer, Northrop Aircraft, Inc., Anaheim, Calif.
Deutsch, K. T., electrical engineer, Bureau of Reclamation, Denver, Colo.
Doughty, H. C., distribution superintendent, The Ohio Power Co., Lima, Ohio.
Douglass, M. E., development engineer, General Electric Co., West Lynn, Mass.
Dreier, T., engg. development manager, telechron dept., General Electric Co., Ashland, Mass.
Drummond, C. L., general meter supt., Georgia Power Co., Atlanta, Ga.
Edmonds, H. M., elec. operations supervisor, Public Service Co. of Colorado, Denver, Colo.
Ellis, J. P., factory contact engineer, General Electric Co., Pittsfield, Mass.
Fenton, N. L., electrical engineer, W. H. Eddy Electric Products, Inc., Phoenix, Ariz.
Fernbach, J. D., production engineer, International Business Machines Corp., Endicott, N. Y.
Fink, W. R., electrical construction engineer, Stone & Webster Engineering Corp., Buffalo, N. Y.
Fisher, L. T., electric design section head, U. S. Corps of Engineers, Portland, Ore.
Fitch, W. E., staff member, Sandia Corporation, Albuquerque, N. M.
Frantti, E. W., engineer, Westinghouse Electric Corp., Pittsburgh, Pa.
Gabel, G. H., project engineer, Pennsylvania Power & Light Co., Allentown, Pa.
Gardner, D. M., electrical engineer, Technicolor Motion Picture Corp., Hollywood, Calif.
Gaskill, W. A., design engineer, Westinghouse Electric Corp., East Pittsburgh, Pa.
Gilman, D. W., engineer, Commonwealth Edison Co., Chicago, Ill.
Glatz, C. E., asst. engineer, Allis-Chalmers Mfg. Co., Pittsburgh, Pa.
Gleisberg, A. E., division electrical engineer, Pacific Gas & Electric Co., Auburn, Calif.
Greenlees, C. R., Jr., industrial control engineer, Westinghouse Elec. Corp., Cheektowaga, N. Y.
Hargreaves, H. R., technical advisor & chief engineer, Balfour Williamson & Co., Ltd., Bogota, Colombia, S. A.
Hart, E. R., electrical engineer, Picker X-Ray Corp., Cleveland, Ohio.
Hershberger, D. D., design engineer, General Electric Co., Fort Wayne, Ind.
Hesse, H. R., electrical engineer, General Electric Co., Ithaca, N. Y.
Hickey, W. H., Jr., production engg. chief, Southern States Equipment Corp., Hampton, Ga.
Hubert, C., assoc, prof. of electrical engg., U. S. Merchant Marine Academy, Kings Point, N. Y.
Hunt, W. T., Jr., asst. prof. of electrical engg., City College of New York, N. Y.
Hunter, R. M., manager, electrical & mechanical dept., Rochester & Pittsburgh Coal Co., Indiana, Pa.
Kettner, R. A., electrical engineer, Howell Lewis Shay & Associates, Philadelphia, Pa.
Klopfenstein, A., substation engineer, Southern California Edison Co., Los Angeles, Calif.
Kusner, L., electrical engineer, Dept. of Water, City of Philadelphia, Pa.
Lawton, W. E., electrical engineer, Aluminum Co. of America, Pittsburgh, Pa.
Leber, C. W., Jr., engineer, Standard Oil Development Co., Linden, N. J.
Lee, R., advisory engineer, Westinghouse Electric Corp., Baltimore, Md.
Legare, T. C. R., design engineer, South Carolina Electric & Gas Co., Columbia, S. C.
Longo, C. V., asst. prof. of electrical engg., Rutgers University, New Brunswick, N. J.
Luther, S. W., asst. chief planning engineer, The Detroit Edison Co., Detroit, Mich.
Mangold, A. O., division engineer, Pacific Power & Light Co., Portland, Ore.
Mathews, T. E., Jr., senior engineer, The Pacific Tel. & Tel. Co., Los Angeles, Calif.
Meisenheimer, R. L., electrical engineer, General Electric Co., Pittsfield, Mass.
Mikhail, S. L., senior lecturer, Ibrahim University, Cairo, Egypt.
Miles, R. A., chief electrical engineer, Alexander D. Crossett, New York, N. Y.
Milkis, M. L., design engineer, Westinghouse Electric Corp., East Pittsburgh, Pa.
Munro, L. M., planning engineer, Doble Engineering Co., Belmont, Mass.
Murray, J. G., project engineer, Lincoln Electric Co., Cleveland, Ohio.
Naylor, H. A., Jr., assoc., engineer, Whitman, Requardt & Associates, Baltimore, Md.
O'Day, J. H., toll traffic engineer, Northwestern Bell Telephone Co., Des Moines, Ia.
Padalino, J. J., member of technical staff, Bell Telephone Labs., Murray Hill, N. J.
Penard, F. P., asst. engineer, Allis-Chalmers Mfg. Co., Boston, Mass.
Poffenberger, C. O., supt. of electrical installations, General Electric Co., Baltimore, Md.
Posluszny, A. G., engineer, Westinghouse Electric Corp., Buffalo, N. Y.
Pusey, J., engineering supervisor, I-T-E Circuit Breaker Co., Philadelphia, Pa.
Rankin, E. C., supervising station engineer, Appalachian Electric Power Co., Roanoke, Va.
Ransom, G. E., electrical design engineer, Quebec Hydro Electric Commission, Montreal, Que., Can.
Rappaport, H., asst. supervisor, Pennsylvania R.R., Fort Wayne, Ind.
Ray, F. H., electrical coordinating engineer, Ebasco International Corp., New York, N. Y.
Redwine, F. R., electrical engineer, Tennessee Valley Authority, Chattanooga, Tenn.
Reed, O. W. B., Jr., senior radio engineer, Jansky & Bailey, Inc., Washington, D. C.
Rehwaldt, R. A., sales engineer, Allis-Chalmers Mfg. Co., Jackson, Mich.
Rescoe, J. M., senior project engineer, Doelcam Corp., Newton, Mass.
Richmond, A. E., director, school of electronics, Multonomah College, Portland, Ore.
Robbins, L. W., application engineer, General Electric Co., Schenectady, N. Y.
Robinson, R. D., research associate, General Electric Research Lab., Schenectady, N. Y.
Ruscher, J. E., relay test engineer, Central Hudson Gas & Electric Corp., Poughkeepsie, N. Y.
Sackler, A. A., chief electrical engineer, Consolidated Diesel Electric Corp., Stamford, Conn.
Saunders, S. E., asst. engineer, Allis-Chalmers Mfg. Co., Hyde Park, Mass.
Schneider, R. H., consulting & application engineer, Westinghouse Electric Corp., New York, N. Y.
Segar, S. G., manager, West Coast branch, Mechanical Products Inc., Burbank, Calif.
Seifert, R. J., transformer design engineer, Moloney Electric Co., St. Louis, Mo.
Shaw, F. D., electrical engineer, American Smelting & Refining Co., South Plainfield, N. J.
Shiring, P. B., manager, area sales engg., Westinghouse Electric Corp., Buffalo, N. Y.
Shoemaker, T. M., supt., Substation Div., Iowa-Illinois Gas & Electric Co., Rock Island, Ill.
Smith, C. L., supt., Light, Water & Sewerage Dept., City of Griffin, Ga.
Smith, W. J., assoc. engineer, Puget Sound Power & Light Co., Seattle, Wash.
Smoot, E. P., design engineer, General Electric Co., Schenectady, N. Y.
Summers, E. W., senior engineer, Westinghouse Electric Co., Buffalo, N. Y.
Taylor, C. L., electrical engineer, Keebler Weyl Baking Co., Philadelphia, Pa.
Terrill, S. F., electrical engineer, Nash Engineering Co., South Norwalk, Conn.
Tharp, N. B., section manager, Westinghouse Electric Corp., Baltimore, Md.
Thompson, B. R., president, Assembly Products, Inc., Chagrin Falls, Ohio.
Thomson, A. G., chief engineer, Burndy Canada, Ltd., Toronto, Ont., Can.
Van Dine, H. A., Jr., technical program representative, General Electric Co., Burlington, Vt.
Vrana, V. E., design engineer, Westinghouse Electric Corp., Buffalo, N. Y.
Waldrip, L. H., partner, L. H. Waldrip Co., Cleveland, Ohio.
Wandersleben, A. E., electrical operations engineer, National Advisory Committee for Aeronautics, Cleveland, Ohio.
Wendler, H. J., senior electrical designer, Public Service Gas & Electric Co., Newark, N. J.
Wheeler, W. R., asst. prof. of electrical eng'g., University of Denver, Denver, Colo.
Widener, B. M., prof. of electrical eng'g., Virginia Polytechnic Institute, Blacksburg, Va.
Wolf, E. G., engg. section head, Sperry Gyroscope Co., Great Neck, N. Y.
Wortman, W. J., operating engineer, Duke Power Co., Charlotte, N. C.
Wright, B. G., design group leader, General Electric Co., Pittsfield, Mass.
Youngdahl, R. C., asst. supt. of electric distribution, Consumers Power Co., Flint, Mich.
Zeller, G. J., asst. engineer, Consolidated Gas, Electric Light & Power Co. of Baltimore, Md.

125 to grade of Member

Applications for Election

Applications for admission or reelection to Institute membership, in the grade of Member, have been received from the following candidates, and any member objecting to election should so notify the Secretary before November 25, 1954, or January 25, 1955, if the applicant resides outside of the United States, Canada or Mexico.

To Grade of Member

Fish, J. P. (reelection), 2005 S. E. 41st Ave., Portland, Oregon.
Halderson, M. H., Phillips Petroleum Co., Bartlesville, Oklahoma
Schlink, F. J., Consumers' Research, Inc., Washington, New Jersey.
Snodgrass, W. A., English Electric Co. of Canada, Ltd., St. Catharines, Ont., Canada.

4 to grade of Member

AIEE Section and Student Branch Meetings

1953-1954

Table I. Section Membership, August 1954; Section Meetings During Year Ending April 30, 1954

Section	AIEE Members August 1954	Number of Meetings	Total Number of Meetings
Akron	220	7	7
Alabama	297	11	
Subsection: Montgomery		3	14
Arizona	238	9	
Group: Technical		16	25
Arkansas	162	10	
Subsection: Northwest Arkansas		9	19
Arrowhead	82	8	8
Beaumont	127	15	
Subsection: Lake Charles		9	
Joint Meeting: Section and Lake Charles Subsection		1	25
Boston	1,074	7	
Groups: Basic Sciences		2	
Communication		1	
Electronics		1	
Industrial Control		1	
Industrial Power Systems		2	
Instruments and Measurements		2	
Insulation		2	
Power Generation		3	
Power Systems		2	
Subsection: New Hampshire		2	
Joint Meeting: Communication and Electronics Groups		1	26
Canton	124	10	
Groups: Electronics Discussion		2	
Management Discussion		3	15
Central Illinois	183	10	
Group: Technical		11	21
Central Indiana	389	9	9
Chicago	2,170	6	
Groups: Basic Sciences		3	
Communication		4	
Electronics		5	
Industrial		5	
Power		5	28
Cincinnati	386	17	
Group: Technical		7	24
Cleveland	1,017	10	
Groups: Basic Science		4	
Electrical Construction		5	
Electronics, Communication and Instrumentation		4	
Motors and Controls		4	
Power Generation and Distribution		5	32
Columbus	274	13	
Subsection: Zanesville		11	
Joint Meeting: Section and Zanesville Subsection		1	25
Connecticut	768	8	
Groups: Communication		3	
Electrical Controls & Measurements		4	
Electric Power Generation, Transmission and Distribution		4	
Industrial Electronics		2	
Industrial Power Application		3	24
Corpus Christi	103	11	11
Dayton	369	6	
Groups: Aeronautics		1	
Electronics		2	
Motors and Control		4	
Power		2	
Subsection: Lima		6	
Joint Meetings: Section and Lima Subsection		1	
Section and Motors and Control Group		1	
Section and Aeronautic Group		1	
Section and Electronics Group		1	25
Delaware Bay	173	10	
Group: Discussion		2	12
Denver	475	12	
Groups: Communication and Electronics		7	
Equipment		6	
Power Systems		6	
Subsection: Black Hills		5	36
East Tennessee	406	16	
Groups: Chattanooga Technical		5	
Knoxville Technical		6	
Subsections: Huntsville		13	
Muscle Shoals		5	
Tullahoma		7	52
El Paso	131	13	13
Erie	173	15	15
Fort Wayne	235	9	9
Georgia	391	9	
Subsection: Savannah		8	17
Hamilton	195	14	
Subsection: London		2	16
Houston	362	10	
Groups: Communication		1	
Distribution		1	
Industrial		3	
Radio Communication		1	
Generation and Transmission		1	
Subsection: Freeport		10	27
Illinois Valley	88	16	
Group: Technical		4	20
Iowa	178	9	
Subsection: Quad-Cities		8	17
Ithaca	360	9	
Group: Technical Discussion		2	
Subsections: Binghamton Area		6	
Binghamton Area Discussion Group		3	20
Jacksonville	89	6	6
Kansas City	429	11	
Groups: Communication		7	
Power		11	29
Lehigh Valley	446	11	
Group: Technical Discussion		20	31
Los Angeles	2,269	7	
Groups: Aircraft		7	
Electronics		7	
Power		8	
Subsection: Boulder City		8	37
Louisville	239	8	
Subsections: Lexington		6	
Paducah		7	
Joint Meeting: Section and Paducah Subsection		1	22
Lynn	398	26	
Subsection: Maine		1	27
Madison	108	9	9
Mansfield	118	8	8
Maryland	863	9	
Groups: Communication		3	
Industrial Electronics		2	
Power		4	
Subsection: Eastern Shore		8	26
Memphis	119	10	10
Mexico	193	9	9
Miami	186	12	12
Michigan	1,070	8	
Groups: Communication		3	
Industry		3	
Power		4	
Science and Electronics		2	
Subsection: West Michigan		9	
Joint Meeting: Science and Electronics and Communication Technical Groups		1	30
Milwaukee	997	7	
Groups: Basic Sciences		3	
Electric Machinery		2	
Electronics Discussion		1	
Power Application and Control Discussion		2	
Transmission and Distribution		3	
Subsections: Fox River Valley		10	
Racine-Kenosha		9	37
Minnesota	492	12	
Subsection: Red River Valley		8	20
Mississippi	95	10	10
Mobile-Pensacola	122	9	9
Montana	116	7	
Subsection: Billings		8	15
Montreal	469	13	
Subsection: St. Maurice Valley		8	21
Nashville	84	9	9
Nebraska	214	10	
Group: Technical		5	15
New Hampshire	111	5	5
New Orleans	306	11	
Subsection: Baton Rouge		10	21
New York	6,019	1	
Groups: Basic Science		3	
Communication		6	
Illumination		7	
Power & Industrial		6	
Transportation		3	
Subsections: Hudson Valley		7	
New Jersey		6	
Joint Meetings: New Jersey and Power and Industrial Divisions		2	
Communication and Transportation Divisions		1	42
Niagara Frontier	389	8	8
Niagara International	160	14	14
North Carolina	394	2	
Subsections: Charlotte		9	
Eastern North Carolina		7	
Mid-State		6	
Western North Carolina		3	
Joint Meeting: Section and Eastern North Carolina Subsection		1	28
Northeastern Michigan	144	13	13
Northern New Mexico	209	14	14
North Texas	657	7	
Groups: Aircraft Electric		6	
Distribution Practices		2	
Industrial Practices		1	
Subsections: Central Texas		7	
Fort Worth		5	
West Central Texas		9	
Joint Meetings: Section and Fort Worth Subsection		1	
Electronics and Industrial Practices Groups		2	
Fort Worth Subsection and Aircraft Electric Group		1	41
Oak Ridge	121	11	
Group: Technical		1	12
Ohio Valley	107	17	17
Oklahoma City	224	9	
Groups: Communication		2	
Electronics		6	
Industrial Practices		6	
Management		1	
Power Systems		7	31
Ottawa	89	11	11
Panhandle Plains	185	9	
Group: Technical		6	15
Philadelphia	2,028	11	
Groups: Aircraft Electrical Systems		4	
Basic Sciences		3	
Communication		4	
Computer		5	
Electronics		3	
Industrial Practices		3	
Instruments and Measurements		3	
Power Systems		3	
Subsection: Atlantic City		8	

Section	AIEE Members August 1954	Number of Meetings	Total Number of Meetings
Joint Meetings: Section and Power Systems Group		1	
Basic Science and Electronics Groups		1	49
Pittsburgh	1,403	4	
Groups: Communication		2	
General Meetings		3	
Industry		3	
Power Generation		3	
Science and Electronics		2	
Transmission and Distribution		3	
Subsections: Centre County		6	
Johnstown		11	
oint Meetings: Section and General Meetings Group		1	
Section and Communications Group		1	39
Pittsfield	377	22	22
Portland	585	18	18
Providence	197	9	
Group: Electronics		3	12
Richland	145	14	14
Ridgway	61	11	11
Rochester	269	18	
Group: Technical Discussion		3	21
Rock River Valley	129	7	7
Sacramento	128	12	12
St. Louis	788	9	
Groups: Basic Sciences		1	
Industrial Apparatus		9	
Power Practices		9	
Subsection: Eastern Division		6	34
San Diego	192	9	
Group: Technical		2	11
San Francisco	1,439	30	
Subsections: Fresno		8	
Honolulu		12	
Reno		8	
San Jose		8	
Shasta		7	
Joint Meetings: Section and San Jose Subsection		1	74
Schenectady	1,177	19	
Subsection: Adirondack		8	27
Seattle	766	7	
Groups: Aircraft		6	
Basic Sciences and Electronics		3	
Power		4	
Subsection: Tacoma		8	
Joint Meetings: Section and Aircraft Group		1	
Section and Transportation Group		1	
Section and Tacoma Subsection		1	31
Sharon	241	9	9
Shreveport	153	10	
Subsection: Monroe		9	19
South Bend	147	11	11
South Carolina	220	3	
Subsections: Charleston		9	
Columbia		9	
Piedmont		8	29
South Texas	153	8	8
Spokane	177	11	
Subsection: Wenatchee		9	20
Springfield	117	8	
Group: Technical		4	12
Susquehanna	149	6	6
Syracuse	416	6	
Subsection: St. Lawrence International		6	12
Tampa	163	1	1
Toledo	185	10	
Groups: Joint AIEE-ASME Management		7	
Motors and Control		1	
Power		1	19
Toronto	734	14	
Groups: Communication		4	
Discussion		9	
Joint Meetings: Section and Discussion Group		1	
Section and Communications Group		1	29
Tulsa	230	9	
Group: Technical Session		19	28
Utah	167	8	8
Vancouver	297	10	
Group: Discussion		7	
Subsection: Vancouver Island		9	26
Virginia	262	3	
Subsections: Hampton Roads		10	
Richmond		6	19
Virginia Mountain	106	7	7
Washington	1,140	8	
Groups: Basic Sciences		1	
Communication-Instrumentation-Electronics		3	
Nucleonics		2	
Power		1	15
West Virginia	128	14	14
Wichita	144	12	12
Worcester	125	8	8
	44,519		1,950

Total Sections, 100
Total technical groups, 115
Total Subsections, 57

Table II. Branch Meetings Held During Year Ending April 30, 1954

Branch	Number of Meetings
*Akron, University of	2
Alabama Polytechnic Institute	10
Alabama, University of	11
*Alberta, University of	6
*Arizona, University of	4
*Arkansas, University of	4
*British Columbia, University of	20
Brooklyn, Polytechnic Institute of	
* Day Division	13
Evening Division	4
*Brown University	3
*Bucknell University	1
*California Institute of Technology	7
*California, University of	28
*Carnegie Institute of Technology	6
Case Institute of Technology	6
Catholic University of America	4
*Cincinnati, University of	7
Clarkson College of Technology	
Clemson A & M College	5
*Colorado A & M College	13
*Colorado, University of	13
*Columbia, University of	6
*Connecticut, University of	4
*Cooper Union	4
*Cornell, University of	5
*Dayton, University of	22
*Delaware, University of	6
*Denver, University of	15
*Detroit, University of	5
*Drexel Institute of Technology	8
Duke University	8
Fenn College	4
*Florida, University of	12
*George Washington University	5
Georgia Institute of Technology	2
Howard University	9
Idaho, University of	14
Illinois Institute of Technology	11
*Illinois, University of	8
Chicago Division	14
*Iowa State College	9
Iowa, University of	20
*John Hopkins University	29
Kansas State College	5
*Kansas, University of	4
Kentucky, University of	7
*Lafayette College	5
Laval University	
Lehigh University	8
Louisiana Polytechnic Institute	10
*Louisiana State University	3
*Louisville, University of	12
*Maine, University of	10
*Manhattan College	6
*Marquette University	4
*Maryland, University of	7
*Massachusetts Institute of Technology	4
*Massachusetts, University of	8
*Michigan College of Mining and Technology	9
*Michigan State College	6
*Michigan, University of	3
Milwaukee School of Engineering	10
*Minnesota, University of	8
Mississippi State College	10
*Missouri School of Mines and Metallurgy	13
*Missouri, University of	6
*Montana State College	11
*Nebraska, University of	11
Nevada, University of	7
Newark College of Engineering	5
*New Hampshire, University of	8
*New Mexico College of A & M Arts	[illegible]
*New Mexico, University of	3
*New York, College of the City of	18
New York University	
* Day Division	24
* Evening Division	2
*North Carolina State College	11
*North Dakota State College	8
*North Dakota, University of	3
*Northeastern University	15
*Northwestern University	19
Norwich University	4
*Notre Dame, University of	7
Ohio Northern University	6
*Ohio State University	11
*Ohio University	9
*Oklahoma A & M College	10
Oklahoma, University of	8
Oregon State College	6
*Pennsylvania State University	7
*Pennsylvania, University of	4
Pittsburgh, University of	17
*Pratt Institute	13
*Princeton University	3
Puerto Rico, University of	1
Purdue University	6
*Rensselaer Polytechic Institute	5
*Rhode Island, University of	4
Rice Institute	2
Rose Polytechnic Institute	7
*Rutgers University	7
Saint Louis University	1
Santa Clara, University of	5
*South Carolina, University of	12
*South Dakota School of Mines and Technology	5
South Dakota State College	1
*Southern California, University of	14
*Southern Methodist University	
*Stanford University	5
*Stevens Institute of Technology	2
Swarthmore College	5
*Syracuse University	6
Tennessee, University of	2
*Texas A & M College	5
*Texas Technological College	13
*Texas, University of	11
Texas Western College Sub-Branch	7
*Toledo, University of	6
*Toronto, University of	18
*Tufts College	5
*Tulane University	7
Union College	3
United States Naval Academy	4
*Utah, University of	11
Vanderbilt University	13
*Vermont, University of	5
*Villanova College	16
Virginia Military Institute	9
*Virginia Polytechnic Institute	21
*Virginia, University of	7
Washington, State College of	9
*Washington, University of	19
*Washington University	10
*Wayne University	9
*West Virginia University	5
*Wisconsin, University of	8
*Worcester Polytechnic Institute	4
*Wyoming, University of	12
*Yale University	7
	1,137

TOTAL BRANCHES 135
* Joint AIEE-IRE Branches (94)

New "Rate-Grown" Process Is Used for Mass Producing High-Frequency Transistors

The General Electric Company has announced that it is tooling for the mass production of low-cost high-frequency transistors. The large quantity production of the transistors has been made possible through development of a "rate-grown" method of mass producing essential transistor elements.

Dr. W. R. G. Baker, vice president and general manager of the company's Electronics Division, said that as a result of the huge quantities of uniform transistor elements it is now possible to produce by the rate-grown process, prices of the transistors should become competitive with vacuum tubes.

The mass production of perhaps many millions a year will get under way within the next two years, depending on the speed of the electronic industry in designing circuits employing the new extremely high-frequency transistors. A limited production will begin in 1955 at their Syracuse plant.

The rate-grown process was invented by a General Electric physicist, Dr. Robert N. Hall, of the company's research laboratory at Schenectady. He found that it was possible to produce the transistor elements in large quantities—several thousand at a time—from the germanium refining process itself. His method involves introducing special impurities, gallium and antimony, and varying the heat controls during the crystal-growing process. By this method, as many as 100 wafer-thin layers of specially treated germanium in a 6-inch ingot are formed.

The ingot is then diced into bars each several thousandths of an inch long with a layer through the center. The layer in the center of each bar does the work of a grid. The sections of the transistor bar on either side of the layer take the place of the cathode and plate in a tube.

Using the new method, several thousand transistors can be produced from the yield of each ingot. A remarkable feature of the rate-growing process is that conditions of single-crystal germanium growth can be varied so that transistor bars having optimum operating characteristics can be obtained at will and in quantities of thousands at a time.

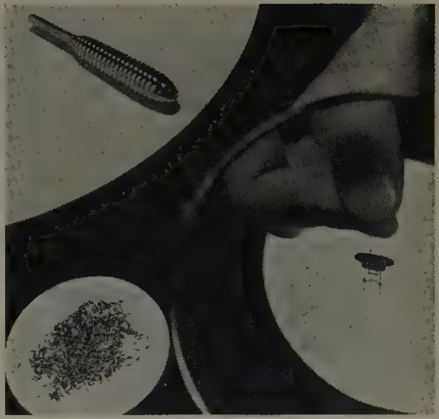
At the present time small quantities of finished transistors, approximately a few hundred a week, are being fabricated on a pilot line in Syracuse for engineering and military evaluation and ultimate sampling to design groups.

Rate-grown transistor ingots are presently being produced at the rate of 1 approximately every 10 days to keep the pilot line supplied. It takes only 2 hours to produce 1 ingot.

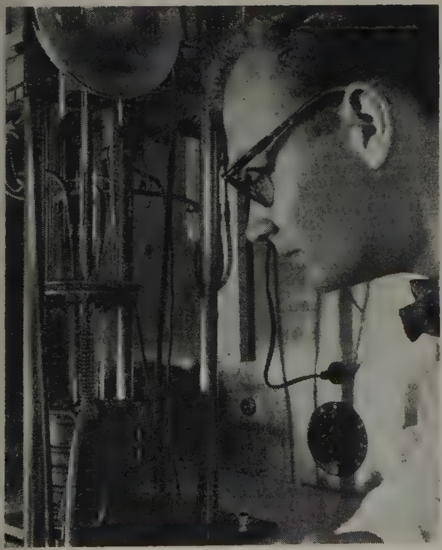
The fabrication process consists principally of attaching leads to the transistor bars. It is in this area of transistor production that General Electric is presently mechanizing.

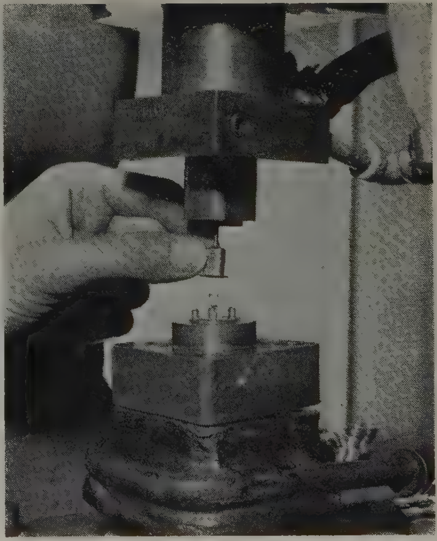
When leads are attached to the transistor bars in the triode configuration, usable gain up to 15 megacycles will result. Tetrodes made from the transistor bars will give usable gain up to 150 megacycles. Oscillations from the transistor triodes may be obtained up to 35 megacycles, while from the tetrode transistors, oscillating frequencies up to 300 megacycles are obtainable.

It has been found that the rate-grown transistors will operate in the ambient temperature conditions and under the environmental characteristics of military and high-class commercial electronic equipment.



Three important steps in General Electric's new method of transistor production are illustrated. The ingot in the upper left corner was produced in 2 hours by the "rate-grown" method, then sliced into thousands of tiny bars, shown in lower left. The bar with leads attached becomes a transistor; simplicity of transistor construction is shown, magnified view, on right





(Left). William Engeler, General Electric design engineer, checks the progress of a crystal growing in a resistance-type furnace, the first step in the production of rate-grown transistors. The characteristics of each of the 2,000 transistors to be made from the single crystal ingot have been produced in it during the drawing process. (Center). A close-up view of the base-lead wire, half the thickness of a human hair, being attached to the transistor bar. On the present pilot line this is a hand operation. It is in this area of production that General Electric is presently mechanizing. (Right). The header with the rate-grown transistor and attached end-leads and base-lead is placed in the special main-seal welding machine. The cap will be welded to the header to provide protection to the transistor assembly. Later, the air will be exhausted from the device. The hermetically sealed unit will then be free from possible air-borne contamination agents such as moisture and various gases

Electronic equipment using the new rate-grown transistors have been successfully operated in temperatures in excess of 85 C for many hundreds of hours.

The basic research, development, and product refinement work was carried on under a joint Army-Navy-Air Force contract administered by the Air Force.

International Electrotechnical Commission Holds 50th Anniversary Meeting

More than 800 delegates from 21 nations, plus several hundred members of their families, attended the 50th anniversary meeting of the International Electrotechnical Commission (IEC) held in Philadelphia from September 1 through 16.

The United States had the largest delegation with 352 persons, followed by Great Britain with 96, France 46, Italy 36, Sweden 35, The Netherlands 32, and Switzerland 20. The Soviet bloc of nations did not attend.

A total of 258 morning and afternoon sessions were held by the 49 IEC technical committees that met.

At the Jubilee Banquet, attended by 625 persons, A. C. Monteith welcomed the gathering as president of AIEE. Walker Cisler, Detroit Edison Company, was toastmaster and Don Mitchell, Sylvania Electric Products Company, delivered the main address, "Standardization, Foundation of International Progress."

Richard C. Sogge, General Electric Company, president of the United States National Committee of the IEC, presided.

At the Jubilee Day luncheon, Dr. Comfort A. Adams, past president of the AIEE and first president of the American Standards Association, was guest of honor. He is one of the three living U.S. founding members of IEC and is the only survivor among those Americans who read papers at the St. Louis meeting in 1904.

Dr. Harold S. Osborne, former chief engineer of the American Telephone and Telegraph Company, president of IEC, presided at the Jubilee Day ceremonies.

No fewer than 43 International Recommendations were brought to the final stages of approval at the meeting. This is more world electrical standards than IEC had produced in its 50-year history. Those which were approved in final form, included standards on Electrical Equipment Installed on Motor Vehicles, High-Voltage Circuit Breakers, Porcelain Insulators for Overhead Lines, Electronic Tube and Valve Bases, and Electronic Tube and Valve Outlines.

Viscount Waverley of England, former Chancellor of the Exchequer, Home Secretary and president of the British Standards Institution stated, "The increasing complexity and variety of electrical equipment today call for greater efforts towards international understanding and agreement not only on definitions but also on assessment of performance and testing. Otherwise, the safety and other regulations of one country—necessary as they are—may form a serious barrier to imports and prevent the dissemination of the best practices and techniques".

"The existence of independent national standards which are not basically comparable can seriously cripple international trade and reduce the efficiency of national industries which have to produce a variety of types of the same article for different markets."

Don Mitchell, at the Jubilee Banquet said, "If atomic energy is used principally as a source of heat, to run conventional generating equipment, the industry will certainly not undergo any drastic revolution. However, the story will be different if an efficient and practical method is developed for generating electric power directly from atomic energy. Such an achievement would change the entire concept of power distribution, and widespread distribution networks could conceivably become outmoded..."

Dr. H. S. Osborne, president, International Electrotechnical Commission (left) receives gold plate presented by Dr. Hilding Tornebohm to IEC on behalf of the International Organization for Standardization. Dr. Tornebohm, (Sweden) is president of ISO. The presentation took place at the Golden Jubilee Banquet of the IEC

Speakers at the Golden Jubilee Day celebration of the International Electrotechnical Commission (left to right): Sir Vincent DeFerranti, representing the World Power Council; The Right Honorable Viscount Waverley, representing the United Kingdom; Charles E. Saltzman, Under Secretary of State for Administration, who welcomed delegates from 20 countries on behalf of the U.S. Government; Dr. H. S. Osborne, president, International Electrotechnical Commission; Dr. Lee A. Du Bridge, president, California Institute of Technology; and General E. E. Wiener, president, Electrotechnical Committee, Belgium

Series of Atomic Tests to Be Conducted in 1955

The Atomic Energy Commission is advising public officials, stockmen, miners, and others in southwestern Utah and southern Nevada that it is preparing its Nevada Proving Ground for a series of atomic tests commencing early in 1955, probably about mid-February. The series will conform generally with those previously conducted in Nevada, including participation and support by the Department of Defense and Federal Civil Defense Administration.

Major Advances in Color Television Open Way to Mass Production

Three new major developments in color television, recently demonstrated by the Radio Corporation of America at the David Sarnoff Research Center, Princeton, N. J., will open the way to early mass production of color television sets within the reach of the consuming public. Each of the developments represents "years of scientific and engineering endeavor telescoped into a memorable few months," according to E. C. Anderson, executive vice-president, RCA commercial department.

Described as milestones in the march toward commercial color television, the three developments were summarized by Dr. E. W. Engstrom, executive vice-preisdent, RCA research and engineering.

The first major development—the 21-inch color picture tube—provides excellent color; with size, picture brightness, picture quality, and contrast comparable to present popular black-and-white tubes. There are several important new features embodied in this tube which contribute to high performance, lower cost, and ease of production. The round metal envelope construction has given tubes of considerably ligher weight, and one that weighs no more than a typical black-and-white picture tube. A new and shorter electron gun and a wider deflection angle have reduced the length of the tube, and gives a more compact color set. An improved shadow mask and mounting system facilitate assembly of the tube and ensure a picture that will be excellent out to the edges, will cover the entire face of the tube, and will be of a brightness comparable to black-and-white. The simplified construction of this 21-inch tube will allow it to be manufactured at reasonable cost in large quantities.

The second major development—the color equalizer—is a new component which improves set performance and further reduces the cost of color receivers. The relationship between the phosphor dots on the screen and the holes in the shadow mask is determined during manufacture by light beams emanating from small light sources. When a completed tube is operated, electron beams take the place of these light beams. Under ideal conditions, the electron beams and light beams follow corresponding paths. In the presence of magnetic fields, however, such as the earth's field or magnetic fields from local sources, the electron beams may no longer follow paths exactly like those of the light beams. To minimize such disturbances, tubes have been protected up to now with a conical magnetic shield which was effective in shielding the small end of the tube cone, but relatively less effective near the tube face. A rim coil in the form of a loop was placed near the plane of the phosphor plate, in addition to the magnetic shield. In increasing the diameter of color tubes, the deflection angle was increased. This in turn made these larger color tubes more sensitive to extraneous magnetic fields particularly near the picture edges.

The new color equalizer performs the function of the rim coil but, unlike the rim coil, its effects may be controlled at various points around the circumference of the color tube face. It makes unnecessary either a magnetic shield or the rim coil. The net result is a better, more positive effect, and a reduction in cost of the receiver. The color equalizer is a sectionalized magnetic field produced by permanent magnets that can be adjusted in position in an assembly placed around the front rim of the color tube. This assembly is separate from the tube itself. The equalizer consists of 2 bands of soft iron which serve as pole pieces, operating together with 8 permanent magnets. Each of these magnets may be adjusted by rotation in its fixed position on the bands, affording control of the magnetic field near its location. This individual adjustment affords selective control around the face of the color tube, permitting compensation for unwanted magnetic fields. The color equalizer thus permits the electron beams to strike the phosphor dots accurately, and the assembly may be adjusted simply and easily to minimize the disturbing effect of magnetic fields in any location where the color set may be placed. The fine adjustment permitted by this arrangement will assure color purity even under adverse circumstances.

The third major development—the new, simplified color receiver—RCA has achieved a very substantial reduction of circuit complexity without sacrifice of performance. This receiver has reduced by one-third the circuitry required for color television sets. It employs 28 tubes counting the picture tube and draws less than 300 watts from the power line. This simplified receiver covers all television channels, both uhf and vhf, and there is more than ample reserve capacity in all circuits to accommodate low limit tubes and low line voltage.

The timetable calls for industry sampling of the 21-inch color tube in November 1, 1954, and for the appearance in the market of the first 21-inch color sets before the end of this year with production in quantity by early 1955. RCA is following the policy of sharing with its competitors its advances in color television so as to encourage early production of improved equipment on the widest scale.

Reporting on plans for color broadcasting Robert W. Sarnoff, executive vice-president of the National Broadcasting Company, said, "By January 1, 1955, we expect at least 82 stations on the NBC network will be color connected and equipped to transmit network programs in color. At that time, about 87 of all television families in the country will be within range of the NBC color service—a tremendously rapid development that all took place within the past year."

Submarine Telephone Cable to Be Installed in Alaska

Construction is in progress on a 370-mile U. S. Army Signal Corps submarine telephone cable system linking Skagway and Ketchikan, and other Alaskan points.

The Signal Corps cable is being manufactured by the Simplex Cable Corporation at Portsmouth, New Hampshire. When completed, an Army cable ship will transport it via the Panama Canal to Ketchikan for cable-laying operations next spring.

It is expected that the new cable will be joined at Ketchikan with an 800-mile submarine cable being planned by the American Telephone and Telegraph Company to furnish additional communications between that Alaskan point and Port Angeles, Washington.

The entire system is expected to be completed by late 1956 and will provide a capacity of 36 telephone circuits. Telephone service between Alaska and the United States is currently handled over 14 radio and landline circuits operated by the Alaska Communications System, a branch of the Army Signal Corps. Certain of these facilities will continue to be operated as a supplementary system.

Future Meetings of Other Societies

American Welding Society. National Fall Meeting. November 1–5, 1954, Sherman Hotel, Chicago, Ill.

Association for Applied Solar Energy. World Symposium. November 2–5, 1954, Phoenix, Calif.

Steel Founders' Society of America. Annual Technical and Operating Conference. November 3–5, 1954, Carter Hotel, Cleveland, Ohio

Institute of Radio Engineers. East Coast Conference on Airborne and Navigational Electronics. November 4–5, 1954, Sheraton-Belvedere Hotel, Baltimore, Md.

Louisiana Polytechnic Institute. 3d Annual Instrumentation Conference. November 4–5, 1954.

Pennsylvania Electric Association. Fall Meeting, Transmission and Distribution Committee. November 4–5, 1954, Alexander Hotel, Hagerstown, Md.

American Petroleum Institute. 34th Annual Meeting. November 8–11, 1954, Conrad Hilton Hotel, Chicago, Ill.

Polytechnic Institute of Brooklyn. Symposium on Modern Advances in Microwave Techniques. November 8–10, 1954, Engineering Societies Building, New York, N. Y.

Illinois Institute of Technology. Armour Research Foundation, Electronic Computer Conference. November 8–10, 1954.

Industrial Management Society. Annual Time and Motion Study and Management Clinic, November 10–12, 1954, Sherman Hotel, Chicago, Ill.

Society of Naval Architects and Marine Engineers. 62d Annual Meeting. November 10–13, 1954. Waldorf-Astoria Hotel, New York, N. Y.

Purdue University. 2d Engineering Graphics Conference. November 11–12, 1954.

American Society for Quality Control–Institute of Radio Engineers. National Symposium on Quality Control and Reliability in Electronics. November 12–13, 1954, Statler Hotel, New York, N. Y.

American Standards Association. 5th National Conference on Standards and 36th Annual Meeting, November 15–17, 1954, Hotel Roosevelt, New York, N. Y.

Operations Research Society of America. Fall Meeting. November 19–20, 1954, Sheraton-Park Hotel, Washington, D. C.

American Society of Mechanical Engineers. Annual Meeting. November 28–December 3, 1954, Statler Hotel, New York, N. Y.

American Society of Refrigerating Engineers. 50th Annual Meeting. November 28–December 1, 1954, Ben Franklin Hotel, Philadelphia, Pa.

1st International Automation Exposition. November 29–December 2, 1954. 242d Coast Artillary Armory, New York, N. Y.

21st National Exposition of Power and Mechanical Engineering. December 2–7, 1954. Philadelphia, Pa.

(Top). Walter Roman, Westinghouse Electric Corporation, makes adjustments on mechanism used to activate the automatic shovel at Shippingport, Pa. This mechanism was operated from Denver, Colo., when President Eisenhower waved an atom rod to start construction of Duquesne Light Company's $45-million - dollar atomic power plant. (Bottom). The 14-ton shovel moves forward without an operator and dumps 2 cubic yards of earth in the ground - breaking ceremony

Ceremony for First Plant Powered by Atomic Energy

President Eisenhower, in a television and radio address, waved a radioactive wand from his summer headquarters at Denver, Colo., on Labor Day; that started a machine moving forward digging earth at Shippingport, Pa., for the $45,000,000 plant to be built by the Atomic Power Division of the Westinghouse Electric Corporation for the Duquesne Light Company of Pittsburgh, Pa. Over-all supervision of the plant's construction rests with the Atomic Energy Commission. It is planned to produce a minimum of 60,000 kw of electricity.

The unique ground-breaking ceremony was the result of an intricate series of controls and telephone circuits that enabled President Eisenhower to operate the crawler-shovel from 1,300 miles away. Television viewers saw the president wave a radioactive wand near a Geiger counter which activated a pointer on a scale. As the pointer moved across the meter scale, near the extreme right of its travel it actuated the electrical signal starting the shovel operation. The signal was transmitted by interrupting a 400-cycle carrier on dual telephone circuits from Denver to Shippingport. There was continuous direct telephone connection during the operation between the two points.

The interruption of the 400-cycle carrier operated a relay to start an electric sequencing switch mounted on the shovel. The sequencing switch activated solenoid valves controlling the hydraulic cylinders connected to the operating levers of the shovel. The power for the sequencing switch and the solenoid valves was provided by a battery. The hydraulic supply for the operating cylinders was from large tank mounted on the back of the shovel.

The ground-breaking ceremony for the atomic power plant was "...a most dramatic moment...an inspiring moment, a solemn moment," in the words of AIEE Past President Everett S. Lee. Mr. Lee attended the ceremony as AIEE representative on the Advisory Committee on Industrial Information of the AEC.

Atomic Industrial Forum Meeting on New Atomic Energy Law

Businessmen and industrial research experts attended a meeting September 27 and 28 in New York, N. Y., on "The New Atomic Energy Law—What It Means to Industry."

The meeting was sponsored by the Atomic Industrial Forum, an industrial association composed of 170 companies, research institutions, and labor organizations and some 600 individuals active in the atomic energy field.

Included in the meeting were descriptions and interpretations of the recently-enacted atomic energy law by William Mitchell, the general counsel of the Atomic Energy Commission, as well as five other atomic legal experts including Everett Hollis, former general counsel, now of the General Electric Company in New York, and Oscar Ruebhausen, chairman of the New York City Bar Association Committee on Atomic Energy.

Dr. T. Keith Glennan, former atomic energy commissioner, now president of Case Institute of Technology in Cleveland, described "The New Industry-Government Partnership in Atomic Energy." He said . . . "what the government does in the area of information dissemination will to a large extent indicate whether it regards its new associate—industry—as a true partner or something much less. . . . In practice, I think the Commission must now permit people outside of its own program who are not security risks to have access to the classified information which they will need to educate themselves in atomic energy and to undertake projects which they—and not necessarily the government—will consider to be worthwhile, and on which they—and not the government—will risk the money. Furthermore, I believe the government must permit these people, if they wish, to exchange classified information among themselves without going through government channels and without first having to secure the approval of the government."

A highlight of the two-day meeting was a description of "What Industry Sees Ahead" in atomic energy under the new law by representatives of 7 leading atomic facility and equipment manufacturers. They were: American Machine & Foundry Company, Babcock & Wilcox Company, Nuclear Development Associates, Sylvania Electric Products, Inc., Victoreen Instrument Company, Vitro Corporation of America, and Westinghouse Electric Corporation, builder of the nation's first atomic power plant.

Eugene B. Hotchkiss, vice-president of the Vitro Corporation of America, said, "Our company recognizes that the new law brings industry a responsibility as well as an opportunity. We are doing our best to shoulder our part of that responsibility. We hope to share in equal measure in the opportunity."

Walter E. Kingston, general manager of the Atomic Energy Division of Sylvania Electric Products Inc., said his firm was confident that low-cost power produced by means of atomic energy will become a reality within the next five to ten years because of progress now being made in the development of nuclear fuels and components of atomic reactors.

Isotope Laboratory to Be Built at General Motors Center

General Motors Research Laboratories announced plans to use radioactive isotopes in peacetime engineering and research studies.

Charles L. McCuen, General Motors vice-president and general manager of Research Laboratories Division, said the program would include construction of an isotope laboratory at the General Motors Technical Center. "We expect to use radioactive isotopes in developing sensitive and delicate new techniques for research in various fields of science," he said. "We will use them not only on advanced projects in our laboratories, but also will open this facility to all General Motors divisions."

It will be one of the largest privately owned industrial isotope facilities in the United States. Within its walls work will be confined to isotope research, the so-called "tracer" studies—not research in nuclear physics or engineering of atomic piles for power. Isotopes, because they can be followed through series of chemical and physical reactions, are adaptable to many phases of automotive and other types of research in which General Motors is engaged.

In the chemical field, for instance, researchers may be able to learn more about engine combustion or durability of paints and finishes. In industrial metal working, it may be possible to learn more about tool wear, design, materials, and lubrication. In many phases of plating and metallurgy, radioactive "tracers" will provide clues to improved techniques and materials.

The use of radioactive isotopes is authorized under strict criteria by the AEC, which controls the entire supply of radioactive materials. Its safety codes, both for research personnel and residents of areas near the Technical Center, are strictly administered by periodic AEC inspections. Elaborate safeguards will be provided in the building and its equipment for handling radioactive materials so that contamination of the laboratory and the surrounding community will be impossible. This will include an approved system of waste disposal.

Atomic Energy Commission Authorizes Power Reactor Study

Lewis L. Strauss, Chairman of the U.S. Atomic Energy Commission, announced that the Commission has authorized a nuclear power study by the Pennsylvania Power and Light Company, of Allentown, Pa. This study is the fifteenth to be undertaken under the Commission's industrial participation program.

The company will make the detailed study at its own expense of the economic and engineering feasibility of a large-scale, nuclear-fueled power plant for use in its own system. The AEC will make available to cleared personnel of the company technical data on reactor development and will arrange for visits to AEC laboratories and reactor installations.

The agreement is for one year, at the conclusion of which the company will report its findings to the AEC and make recommendations as to the installation and operation of a nuclear power plant.

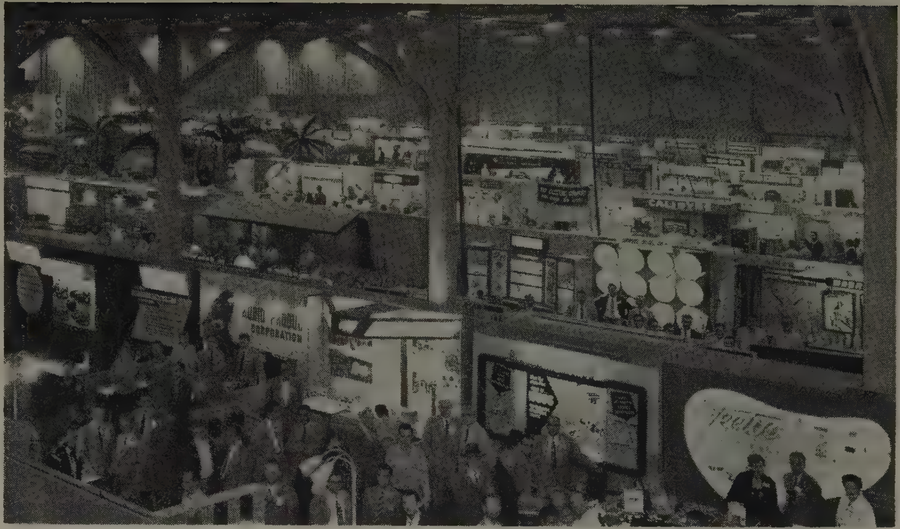
Engineers Find Many New Uses for Copper and Its Alloys

Copper and its alloys have solved many new problems in the use of metals in the field of electronics. Expensive machining on wave guide hardware is eliminated by use of sections cut from extruded copper alloy shapes. Coaxial cable copper tube is preferred because of its high conductivity, fine surface finish, accuracy of dimensions, and ability to be fabricated, bent, and soldered. One type of copper in very thin sections is ideal for metal-to-glass seals since the glass readily wets the copper, and the thin sections adjust themselves to prevent cracking of the glass.

In color television sets there is a critical screen made from thin strips by etching an extremely large number of fine holes. Many metals were tried, but a copper-nickel alloy was found the best to meet the severe conditions because of the uniform structure, excellent etching characteristics, and permanence of dimensions under conditions of use.

Brass mill industries have co-operated with manufacturers of large turbogenerators to solve a problem of heat dissipation which has limited the size of units. One solution has made use of hollow windings constructed of extruded interlocking brass shapes to permit circulation of cooling gases.

WESCON Exhibition



The Pan Pacific Auditorium in Los Angeles, Calif., was the scene of the exhibition for the Western Electronic Show and Convention (WESCON) on August 25–27, 1954. More than 500 exhibit booths featured displays of interest to electronic engineers. The show and convention is sponsored annually by the Institute of Radio Engineers and the West Coast Electronic Manufacturers Association

New York Engineering Schools Plan for Centennial Anniversaries

Polytechnic Institute of Brooklyn and New York University's College of Engineering both announce plans for celebrating their centennial anniversaries.

Polytechnic Institute of Brooklyn, the country's second largest engineering school, will emphasize interpretation of its centennial theme, "Science, Engineering, Research for Human Well-Being," during its centennial year, according to the plans disclosed today by President Harry S. Rogers.

Chartered in 1854 as the Brooklyn Collegiate and Polytechnic Institute, the school admitted its first class of 267 students in September 1855, and was one of the pioneers in evening education in the United States. Today over 6,500 students attend its undergraduate and graduate schools in day and evening sessions. Approximately $2,000,000 is utilized for research annually at Polytechnic for government and industry as well as that sponsored by the school. Typical programs include such widely diverse investigations as the thermal effect of friction at supersonic speeds, the structure of proteins, purification of water, the structure of radar domes for use in the arctic, and analysis of color additives in foods.

In revealing plans for the celebration, which will be held during the 1954–55 academic year, Dr. Rogers said, "Alongside the vigorous philosophy of western man we must range the genius of the scientists and engineers, if we are to understand fully the rise and greatness of modern civilization.

"We hear much today about the misuse of scientific knowledge and the creation of devices and releasing of forces which might ultimately destroy civilization. The political and moral failures of the world are not the fault of the scientist or engineer in his particular professional capacity, but only in his status as a member of the society in which these things occur."

Scores of scientific, engineering, and educational symposia will bring together leading scholars from all corners of the world to meet under Brooklyn Polytechnic auspices during the centennial celebration. The meetings of several national societies have been scheduled to coordinate with the celebration of Polytechnic's anniversary.

Plans for observance of New York University's College of Engineering 100th anniversary were announced recently by Dean Thorndike Saville. Among the events scheduled for the year are three major convocations and conferences of national and international science and professional groups. Through the centennial year, scientific and professional meetings and conferences, students, alumni, public events, exhibitions, and publications will expand on the theme "Teaching and Research Build the Future."

"Although the 100 years of engineering education at New York University cover an age of unparalleled material progress by mankind, in observing the Centennial we look forward to even greater progress in the coming century," said Dean Saville in a statement prepared for the opening of the Centennial year.

"Engineering and science in the next 100 years conceivably can satisfy the basic wants and needs of men everywhere. Technology alone will not solve the world's problems; but when coupled with freedom and justice for all, it will assist powerfully in creating improved conditions of living and help to build a firm base for an enduring peace."

From an enrollment of fewer than a dozen students in its first decade, the school grew to pass the 100 mark for the first time in 1902. The present enrollment is 3,147, of which 1,125 students are in the day division, 1,150 in the evening division, and 872 in the graduate division. Its research division, conducting research on contracts whose present annual dollar total is about $2,235,000, is the sixth largest university engineering research center in the United States.

New Research Center for Testing Steel

By determining the load that can be applied repeatedly to steel samples without causing failure, detailed information on how to build and fabricate greater safety into steel conveyances and structures will be available from the new Research Center now under construction by U. S. Steel Corporation near Pittsburgh, Pa. Such research into the endurance limits of steels will make it possible for engineers to design within safe limits without excessive weight or waste.

One of the machines to be used in this research activity is a magnetic fatigue tester. Samples of steel from 24 to 36 inches in length, and up to 2 inches thick and 5 inches wide can be subjected to controlled vibrations at the natural frequency of the test piece.

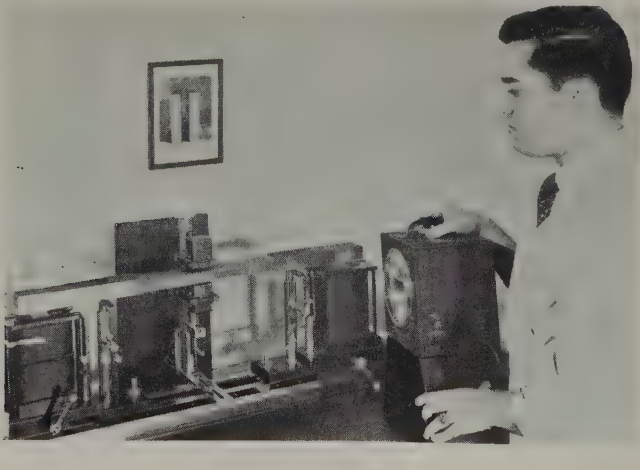
The machine consists of 2 rubber-padded supports upon which the test piece is placed, an electromagnet located at each end, pick-up coils located at the center of the sample, a power unit with controls, a stroboscopic light, and a microcomparator to measure vibration amplitudes.

An alternating current is supplied to the end magnets to set the steel sample vibrating at its natural frequency depending on the dimensions of the piece. The center pick-up coils translate the motion into electrical impulses which feed back to control the power unit at the natural frequency of the sample.

When a crack develops in the test specimen, its natural vibrational frequency changes. This change upsets the rhythm of impulses from the pick-up coils to the power unit and the machine automatically stops. By use of the microcomparator, the research scientist can easily measure the amplitude of the vibration or the amount of bending.

The stroboscopic light is used to determine the location of very small fatigue cracks. This is done by adjusting the light from the stroboscope to a frequency slightly higher or slightly lower than that of the vibrating sample. In this light, the test piece appears to be bending very slowly and its surfaces can be carefully examined for very small cracks.

Tests indicate that if a specimen can endure 10,000,000 cycles at a certain amplitude without failure, it will withstand an infinite number of vibrations at that amplitude. The machine also makes possible the determination of the fatigue limits of steels with various surface finishes and with welds, rivets, and other fastenings.



Magnetic fatigue testing machine at U. S. Steel Corporation's Research and Development Laboratory, in which a steel sample is subjected to controlled vibration to determine its resistance to fatigue failure

Largest Turbogenerator Unit Will Be Constructed

Plans to build a power generating station that will establish new "highs" for efficiency, steam pressure, and temperature have been announced by R. G. Rincliffe, president, Philadelphia Electric Company. "Representing an initial investment of some $45,000,000, the new power plant, which will be located at a point yet to be determined, will serve the rapidly growing Delaware Valley," Mr. Rincliffe stated.

The 275,000-kw turbine generator unit—the largest ever ordered—will be built by the Westinghouse Electric Corporation. The steam generator for the plant will be built by Combustion Engineering, Inc., and will supply steam to the turbine at the highest steam pressure and temperature of any existing or projected power plant in the world—5,000 psi and 1,200 F, although initial operation will be at 1,150 F. The expected plant heat rate for steam conditions of 5,000 pounds per square inch and 1,150 F is 8,400 Btu per whr, some 600 Btu less than the heat rate for the most efficient existing power station.

The tandem-compound 4-cylinder turbines will operate at 3,600 rpm, utilizing triple-flow exhaust to the condensers, and double reheat. Two pumps, each of 75,000 gallons per minute capacity, will provide cooling water to condense the steam. Nine stages of feedwater heating are contemplated. The generator for the plant will be rated at 352,000 kva, 3 phase, 60 cycles, 24,000 volts, and 3,600 rpm. It will be self-ventilated with shaft-mounted fans, and will employ hydrogen inner-cooling of rotor and stator conductors.

Patents Released to Public by Atomic Energy Commission

Twenty-five patents owned by the U. S. Government and held by the Atomic Energy Commission have been released by the Commission. Nonexclusive royalty-free licenses will be granted to make nonsecret technological information available for use by industry. The list of patents includes titles as: Polaroscope, Neutron Scintillation Counter, Ion Beam Measuring Device, Shock or Vibration Isolating Means, Radioactivity Measurement, Water Cooled Insulator, Isotope Separator, and Electronic Controlled Pumping System. Applicants for licenses should apply to the Chief, Patent Branch, Office of the General Counsel, U. S. Atomic Energy Commission, Washington 25, D. C.

Defense Procurement to Be Explained by Attorneys

The businessman with an eye on government contracts will be interested in a 6-lecture series on problems confronting defense department suppliers, announced by the Practising Law Institute, New York. Former government lawyers with procurement experience will explain the techniques and procedures beginning November 15 at the New York County Lawyers Association, New York.

The program will help business executives and trainees understand the vital differences between government and other contracts and the problems of financing, price determination, termination, and renegotiation of defense contracts

Television "Booster" System Installed in Mississippi

Future possibility of extending uhf television service into certain areas "blacked out" because of geographic conditions was reported recently by the Radio Corporation of America after successful field-testing of an experimental "booster" system for uhf television stations.

The booster equipment was installed some 37 miles from the main transmitter of Station WJTV, Jackson, Miss. It stepped up field intensities to Grade "A" quality in that area, according to Theodore A. Smith, vice president and general manager, RCA engineering products division.

The booster system was developed after long study of methods for improving coverage of uhf television stations. In addition to a low-powered transmitter, the system includes a highly directional receiving array which picks up the signal from the main transmitter and feeds it to amplifying equipment. The latter, which produces a peak visual power output of approximately 10 watts, then feeds the signal to a special transmitting antenna having a power gain of approximately 100.

Wind Sensing Unit Developed for Measuring Air Currents

The wind's force and direction can be measured electrically by means of a new instrument developed by Baldwin-Lima-Hamilton Corporation, Philadelphia, Pa. The wind sensing unit is used to measure air currents encountered in aircraft research.

Its most important feature is instantaneous response to sudden changes or shock waves. Deflection of the light-weight 2-inch-diameter hollow metal ball is extremely small at the highest wind force for which it was designed.

The pick-up unit is essentially a cylindrical cantilever beam on which there are two independent Wheatstone bridge circuits consisting of *SR-4* resistance wire gauges arranged to measure the strains caused by wind forces in two directions at right angles to each other. Combination of these bending strains provides a means of indicating both the magnitude and direction of air flow by means of simple electronic amplifier circuits and any of several types of indicating or recording instruments.

The principle is applicable for use in water or other liquids as well as in air for the measurement of shock waves, explosion pressures, rates of flow, etc.

Pick-up unit for measuring wind's force and direction

Course in Nuclear Engineering Planned for Fall Term

To keep pace with the tremendous technological advances expected to result from industrial use of atomic energy, many engineers find they must supplement their engineering training with a knowledge of nucleonics.

Illinois Institute of Technology, cognizant of future demands upon engineers, will offer for the first time this fall a new course in nuclear engineering. "Assuming only the background of the engineering graduate, the course is designed to instruct the engineer in the fundamentals of radioactivity and the manipulation and control of atomic energy," was announced by William A. Lewis, dean of Illinois Tech's graduate school.

The course will include development of reactor theory and the history of neutrons in a nuclear reactor; calculation of neutron flux and the diffusion of neutrons by Fick's law; derivation of "pile" equations and related expressions for criticality, moderation, slowing down, multiplication constant age, diffusion length, and buckling, and discussion of reaction kinetics and control.

Council Organizes Group to Meet Nuclear Problems

To meet "the pressing problems of nuclear engineering and the related sciences" with particular interest in "industrial usefulness," Engineers Joint Council announced initial steps toward an organized program of confronting these problems "authoritatively by a group of leading engineers."

In making the announcement, Thorndike Saville, president of the Council and dean of engineering at New York University, commented that "action by this powerful engineering group is further evidence that nuclear energy is well on the way to having important peace time industrial usefulness."

An early invitation will be extended to the societies of physicists and chemists to join the engineers in planning a strong organization was reported by Warren L. McCabe, administrative dean at Brooklyn Polytechnic Institute, chairman of Engineers Joint Council Committee on Recognition of Specialties in Engineering. The movement is expected to bring together most of the country's eminent participants in industrial nuclear development.

Electric Lift Truck Speeds Stock Pick-up Job

A new development for saving man-hours is the high lift "walkie" type electric truck, with travel, steer, and lift controls mounted in a control box on the platform. This Barrett-Cravens Company truck speeds the selection and removal of stock from racks or shelves as the operator never has to leave the platform of the truck during a stock pick-up job. It has changed stock selecting from a two-man to a one-man task.

The complete operation is handled through a control box mounted directly in front of the operator who stands on the front of the truck's platform. Raising or lowering the platform is controlled by push buttons on the operating panel which permit stopping the platform on any level.

Electric lift truck equipped with controls on panel of platform for lifting, lowering, and traveling

Only one handle is used to control the four operations of horizontal travel, forward, reverse, right, or left. This remote control enables the operator to go up and down aisles and steer easily while selecting stock from either side.

Transistor Will Operate at 440 Megacycles

The time when home television sets will use tiny transistors about the size of pencil erasers instead of a large array of vacuum tubes came closer to realization recently with the announcement by Bell Telephone Laboratories of a transistor which will operate at 440 megacycles, higher in frequency than any transistor yet known.

Bell Laboratories, where the original transistor was invented, unveiled its latest member of the family of the "mighty mites" with a talk by Dr. J. M. Early, before the Western Electronics Show and Convention at Los Angeles, Calif. Dr. Early invented the new transistor and was assisted in its development by W. C. Hittinger and Dr. J. W. Peterson.

The ultra-high-frequency device, called an "intrinsic barrier" transistor, can increase an electric signal a thousandfold. In addition to its ability to amplify signals, it may be used as a generator of electric oscillations. Frequencies as high as 3,000 megacycles are theoretically possible.

The new device, like other junction transistors, can operate at extremely low power—as little as a fiftieth of that used by an ordinary flashlight bulb and less than a hundredth of that needed by a vacuum tube. But, unlike earlier transistors, it can also operate at relatively high power, perhaps up to one-half a watt.

LETTERS TO THE EDITOR

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers. Publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

The Electroluminescent Lamp

To the Editor:

I should like to draw your attention to some misstatements of fact concerning the history of electroluminescence, which mar the very interesting article "The Electroluminescent Lamp: A New Light Source" by K. H. Butler, C. W. Jerome, and J. F. Waymouth (*EE, June '54, pp. 524–8*).

Thus, on page 525, column 2, the authors state with regard to the most plausible mode of transfer of energy from the electric field to the activator centers:

"*Direct Field Ionization.* This mechanism requires that in a strong electric field electrons in bound states of activator centers may escape to the conduction band by the well-known wave mechanical tunneling process, as shown in Fig. 5. This process has been suggested independently by Burns,[7] and by Bitter and Vasileff in letters to the authors."

As far as I am aware, this theory was first set forth at a lecture which I gave in March 1952 at the Massachusetts Institute of Technology Conference on Physical Electronics, at which the authors of the article on "The Electroluminescent Lamp" were represented, and also in a note to the *Physical Review* (*vol. 87, Sept. '52, p. 1125*).

It also seems to me that in discussing "spot" formation the authors place the emphasis on a secondary rather than a primary effect. As shown by the microscopic observations on the radiation from a single spot (reported in the *Physical Review* note), the primary fact is that the exciting carrier is an electron. If the carrier were a hole, the spot formation could not be ascribed to the action at the rectifying junction, as the rectifier would operate in the wrong direction.

ARTHUR BRAMLEY

(Allen B. Du Mont Laboratories, Inc., Passaic, N. J.)

About Salaries . . .

To the Editor:

I am writing you in regard to the EJC (Engineers Joint Council) Engineer's Salary Survey. I think that it is the best thing that EJC has done so far. However, I think that there is a great need for further work on this subject.

One of the things that this survey brings out very vividly is that it takes quite a few years for the average engineer to equal the wages of the skilled tradesman. This salary survey is one of the first things done by a major group of engineers to take the shroud of secrecy from the subject of salaries.

I think that a great many of us have watched the young engineer come into industry in the past few years. The chances are that he had to work part time at some trade or manual job to support his family while he finished college. Through this experience he gets a good idea of what wages in industry are. When he finishes school he gets offers from industry. He finds that he can not make too much when he starts in his chosen field, but he thinks that as soon as he gets experience things will be different. After all, the company is not making money on him until it gets him trained. However, as the first few years pass, he gets raises, but they do not bring his salary up to very much above what industry is paying its new graduates. Unless he is a very exceptional man he is likely to become frustrated. He is not sure whether the trouble is with himself or somehow with the system.

To reiterate my original point, this matter of salaries has been much overlooked. The engineering schools do a very efficient job of teaching higher mathematics, but they seem to fall down in teaching how to make money. Information such as this salary survey should be made available to the students so that they can go into their chosen field with their eyes open.

I believe that the AIEE should make a salary survey of its own. The EJC sent out the questionnaires to the entire manufacturing industry and sent them to the employers rather than the employees.

Probably other members of the society would have ideas on this subject. I think that it should be discussed in the "Letters to the Editor" page in *Electrical Engineering.*

OWEN B. TROUT

(2039 Dayton Avenue, St. Paul, Minn.)

NEW BOOKS • • • • •

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

PLANNING GUIDE FOR RADIOLOGIC INSTALLATIONS. Edited by Wendell G. Scott. The Yearbook Publishers, Inc., 200 East Illinois Street, Chicago, Ill., 1953. 336 pages, $10^{1}/_{4}$ by $7^{1}/_{4}$ inches, bound. $8. A manual for all those concerned with the design, construction, or remodelling of installations for radiologic examination and treatment, from the 1-room department to the complex facilities of a large university hospital. Individual chapters are written by specialists and give comprehensive information on all phases of radiologic practice. Full drawings are not included, but suggestions are made regarding space, design, function, and protection.

OPTIQUE. By G. Bruhat. Masson and Cie, Paris, France, fourth edition, 1954. 906 pages, $9^{1}/_{2}$ by $6^{1}/_{4}$ inches, paper. Ffrs 3,000. A comprehensive textbook comprising the following major divisions: fundamental concepts; interference phenomena; diffraction of light; optics of isotropic media, covering polarization, metallic reflection, etc.; optics of anisotropic or unsymmetrical media; and a final section dealing with optical and X-ray spectroscopy, the Zeeman and Stark effects, fluorescence, and phosphorescence.

THE PHYSICS OF THE STRATOSPHERE. By R. M. Goody. Cambridge University Press, 32 East 57th Street, New York 22, N. Y., 1954. 187 pages, $8^{3}/_{4}$ by $5^{1}/_{2}$ inches, bound. $5. The physical properties of the stratosphere considered in this monograph are temperature, composition, dynamical structure, and radiation balance. The book is at once a summary of present knowledge of these subjects and a critical review of the experimental methods employed in studying the stratosphere.

PROBABILITY AND INFORMATION THEORY, WITH APPLICATIONS TO RADAR. By P. M. Woodward. McGraw-Hill Book Company, Inc., 330 West 42d Street, New York, N. Y., 1953. 128 pages, $8^{3}/_{4}$ by $5^{3}/_{4}$ inches, bound. $4.50. One of a series of monographs reporting on research in electronics and applied physics, this volume presents the essentials of probability and information theory in a condensed form. The first two chapters review probability theory and waveform analysis and noise, while the third summarizes the fundamentals of information theory. Chapters 4 and 5 deal with problems of detecting signals in noise, and the last three chapters are devoted to a mathematical treatment of radar along the lines suggested in the preceding pages.

RELAYS FOR ELECTRONIC AND INDUSTRIAL CONTROL. By R. C. Walker. Chapman and Hall Ltd., London, England, 1953. 303 pages, $8^{3}/_{4}$ by $5^{3}/_{4}$ inches, bound. 42s. This is a descriptive survey of the features and uses of relays as switching devices, intended to make some of the less-known controls more familiar to engineers. Opening chapters deal with functions and classification of relays, fundamentals of electromagnetics, relay coils, and contacts. Then follow chapters on d-c and a-c relays, high-speed relays, and time elements in relays. The last two chapters cover methods of control and miscellaneous applications. A list of references follows most chapters.

SOFT MAGNETIC MATERIALS FOR TELECOMMUNICATIONS. Edited by C. E. Richards and A. C. Lynch. Interscience Publishers Inc., 250 Fifth Avenue, New York 1, N. Y., 1953. 346 pages, $8^{3}/_{4}$ by 6 inches, bound. $9. This collection of 35 papers, slightly shortened versions of those presented at a 1952 conference, cover the theoretical and practical aspects of a variety of materials: carbonyl iron, silicon iron, nickel-iron powder cores, and nickel-molybdenum-iron alloys. They also deal with such subjects as theories of high permeability and low coercivity, hysteresis losses, magnetic viscosity, properties of ferromagnetic powders, etc. The volume has a subject and author index.

INTRODUCTION TO NUCLEAR ENGINEERING. By Richard Stephenson. McGraw-Hill Book Company, Inc., 330 West 42d Street, New York 36, N. Y., 1954. 387 pages, $9^{1}/_{4}$ by $6^{1}/_{4}$ inches, bound. $8. A survey of the nuclear-energy field for students, and for engineers who have completed the conventional courses. Following a brief review of nuclear physics, separate chapters discuss fission, the nuclear chain reactor, reactor theory, radiation shielding, materials of construction, and instrumentation and control. There are also chapters on the separation of stable isotopes, chemical separations and processing, and on special techniques such as handling radioactive materials and the design of carriers for shipping them.

LIGHTNING PROTECTION FOR ELECTRIC SYSTEMS. By Edward Beck. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, N. Y., first edition, 1954. 313 pages, $9^{1}/_{4}$ by $6^{1}/_{4}$ inches, bound. $6.50. Basic facts and principles for the solution of protection problems in a practical manner are presented, with the major portion of the text devoted to the valve and expulsion types of lightning arresters and their applications. There are chapters on the protection of transmission-line insulation, distribution circuits, power apparatus, switchgear, transformers, and rotating machines. References are listed after each chapter.

STATISTICAL METHODS IN ELECTRICAL ENGINEERING. By D. A. Bell. Chapman and Hall Ltd., London, England, 1953. 175 pages, $8^{3}/_{4}$ by $5^{1}/_{2}$ inches, bound. 25s. A book on statistical theory written for both students and practicing engineers. Theoretical aspects covered are probability, qualitative classification, frequency distribution, characteristics of distributions, curve fitting, etc. Applications of methods discussed are made to conduction-electrons in metals, waveform analysis, fluctuations in an electric current, quality control, and servo systems.

SYMPOSIUM ON INSULATING OILS. (Special Technical Publication, Number 152.) American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa., 1953. 45 pages, 9 by 6 inches, paper. $1.25. The fifth and latest symposium on insulating oils, held in 1952, was devoted to the single theme of reclaiming and inhibiting of used insulating oil. This report consists of a paper by Frank C. Doble and discussion on the paper. General treatment of the subject covering background, terminology, and a statement of problems, is followed by a description of modern maintenance methods, tests, means for reclaiming oil, effects of inhibition, and principles for a program for reclamation.

INTRODUCTORY CIRCUIT THEORY. By Ernst A. Guillemin. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., 1953. 550 pages, $9^{1}/_{4}$ by $6^{1}/_{4}$ inches, bound. $8.50. A presentation of the basic principles and concepts needed for full understanding of advanced work in network analysis and synthesis. The book provides a coherent exposition of the methods of steady-state and transient circuit analysis, as well as an introduction to synthesis procedures; and develops the "tools" essential for research in network theory, including graphical interpretations and computational aids.

NATIONAL ELECTRONICS CONFERENCE, PROCEEDINGS. Volume IX, 1953. National Electronics Conference, Inc., 84 East Randolph Street, Chicago, Ill., 1954. 958 pages, $9^{1}/_{4}$ by $6^{1}/_{4}$ inches, bound. $5. The papers of the 1953 conference published in these *Proceedings* provide a review of the latest developments in electronics research and applications. The 98 technical reports included are grouped by subject under such headings as circuits, magnetic amplifiers, servomechanisms, computers, transistors, etc.

NEUTRON OPTICS. By D. J. Hughes. Interscience Publishers, Inc., 250 Fifth Avenue, New York 1 N. Y., 1954. 136 pages, 8 by $5^{1}/_{4}$ inches, paper. $2.50. The interference effects of scattered neutron waves and the typical optical effects that result are the phenomena with which this study is concerned. The opening chapter discusses fundamentals of neutron scattering, optics of neutrons in comparison with electromagnetic waves, and the way in which neutron scattering determines refraction, reflection, and diffraction. Chapter 2 gives general features of experimental methods, and the remaining three chapters cover applications to nuclear reactions, analysis of structure, and magnetic properties.

NUCLEAR MOMENTS. By Norman F. Ramsey. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., 1954. 169 pages, $9^{1}/_{4}$ by 6 inches, bound. $5. The first four chapters present introductory material and definitions, descriptions of interactions, methods for measuring nuclear moments, and a summary of significant results in the field and their relation to nuclear theory. These chapters are reprinted from the author's section of volume 1 of "Experimental Nuclear Physics" edited by E. Segrè. The last third of the book is new material on applications to chemistry and solid-state physics.

PRINCIPLES OF INDUSTRIAL PSYCHOLOGY. By Thomas Arthur Ryan and Patricia Cain Smith. Ronald Press Company, 15 East 26th Street, New York 10, N. Y., 1954. 534 pages, $8^{1}/_{2}$ by $5^{3}/_{4}$ inches, bound. $5.50. An introductory survey of the entire field presenting a complete summary of the results of research and practical experiments. It covers selection, placement, motivation, fatigue, and other questions of importance to management, labor, industrial engineers and personnel directors. The authors point out what the industrial psychologist can and cannot do at the present time and suggest directions for future research.

THE PROPERTIES OF GLASS. (American Chemical Society Monograph number 124). By George W. Morey. Reinhold Publishing Corporation, 330 West 42d Street, New York 36, N. Y., second edition, 1954. 591 pages, $9^{1}/_{4}$ by $6^{1}/_{4}$ inches, bound. $16. A survey of all the measurable properties of glass and a review of the literature of the subject. In this revision the author has included all new measurements on glasses of known composition made since the first edition of 1938, new material on complex and commercial glasses, and new sections on the effect of heat treatment and absorbed radiation on the properties of glass.

THE SYNCHRONOUS INDUCTION MOTOR. By J. Griffin. Macdonald and Company, Ltd., London, England, 1954. 136 pages $8^{3}/_{4}$ by $5^{3}/_{4}$ inches, bound. 18s. An over-all review of present-day practice for designers and users. The book opens with chapters on starting, synchronizing, and the elementary theory of this type of motor. Theoretical and operational aspects of such subjects as power factor correction, overload capacity, braking, etc., are then discussed. A separate chapter is devoted to the salient-pole motor, and there is a chapter on mechanical construction. A bibliography of 33 references is included.

ZERSTORUNGSFREIE WERKSTOFFPRUFUNG. Edited by the Institut für Metallforschung, Saarbrücken, and others. Verlag Stahleisen, Düsseldorf, Germany, 1952. 166 pages, $10^{5}/_{8}$ by $8^{1}/_{4}$ inches, paper. DM. 17.60. A compilation of 20 papers dealing with nondestructive testing methods mainly radiographic or ultrasonic, but also including spectrographic, magnetic, electronic, and oil-powder methods. Some specialized applications are described as a dynamic method for determining elastic constants and the checking of the thickness of a rolled material during processing. In French or German only.

ACTIVE NETWORKS. By Vincent C. Rideout. Prentice-Hall, Inc., 70 Fifth Avenue, New York, N. Y., 1954. 485 pages, $8^{1}/_{2}$ by 6 inches, bound. $10.65. Fundamentals of vacuum tube networks and all networks capable of amplification are presented in this book which is intended for the reader familiar with the physics of vacuum tubes and related devices, and with the theory of passive linear networks. Circuits for communications and control are emphasized, but detailed material on the transitor is included and there is discussion of thyratrons, magnetic amplifiers, and position control servomechanisms. References are listed after each chapter.

CALCUL STATISTIQUE DES SYSTEMES ASSERVIS. By Marc J. Pelegrin. France, Ministère de l'Air, Publications Scientifiques et Techniques no. 285, 1953. 156 pages, $10^{5}/_{8}$ by $7^{1}/_{8}$ inches, paper. Ffrs. 1,200. The author provides a mathematical analysis of servomechanism behavior based on the communications theories of Norbert Wiener and Y. W. Lee. The generalization is then applied to nonlinear systems such as relays and automatic airplane pilots.

DIRECT AND ALTERNATING CURRENTS. By E. A. Loew assisted by F. R. Bergseth. McGraw-Hill Book Company, 330 West 42d Street, New York, 36, N. Y., fourth edition, 1954. 637 pages, $9^{1}/_{4}$ by $6^{1}/_{4}$ inches, bound. $7.50. Stresses fundamental principles needed for understanding electric machines. This text is intended for a first course in electrical engineering and a survey course for other engineering students. Introductory chapters, and those on magnetism, electromagnetism, and magnetic circuit, and some others have been rewritten in this edition. The chapter on fuses, switches, and lightning arresters, and most of the chapter on synchronous converters have been omitted, and a chapter on conversion equipment has been added.

ELECTRIC TRACTION HANDBOOK. (Control). By R. Brooks. Sir Isaac Pitman and Sons, Ltd., London, England (distributed in United States by Pitman Publishing Corporation, 2 West 45th Street, New York 19, N. Y., 1954). 322 pages, $8^{3}/_{4}$ by $5^{3}/_{4}$ inches, bound. $6.50. A broad treatment for the general engineering reader of control apparatus for electric trains, trolley-busses, and streetcars. The emphasis is on d-c systems, but a-c systems are surveyed. There is some material on recent developments on 50-cycle single-phase operation, as well as on diesel-electric and gas-turbine-electric traction equipment.

GRAPHICS IN ENGINEERING AND SCIENCE. By A. S. Levens. John Wiley & Sons, Inc., 440 Fourth Avenue, New York, N. Y., 1954. 696 pages, $9^{3}/_{4}$ by 7 inches, bound. $7. Graphics is treated as a means of communication for the engineer and scientist. The first part emphasizes fundamental principles, primarily of orthogonal projection, and applies these to a variety of space problems in engineering. The second part covers standards; representation of threads and fasteners, cams, and gears; dimensioning practices; and the preparation of working drawings. Part 3 deals with graphical analysis and graphic methods of computation. Appendixes give symbols, standards, and other data, and there is a selected bibliography.

Library Services

ENGINEERING Societies Library books may be borrowed by mail by AIEE members for a small handling charge. The library also prepares bibliographies, maintains search and photostat services and can provide microfilm copies of any item in its collection. Address inquiries to Ralph H. Phelps, Director, Engineering Societies Library, 29 West 39th St., New York 18, N. Y.

HANDBOOK OF INDUSTRIAL ELECTROPLATING. By E. A. Ollard and E. B. Smith. Iliffe and Sons, Ltd., London, England, second edition, 1954. 366 pages, $8^{3}/_{4}$ by $5^{3}/_{4}$ inches, bound. 30s. Practical information on the design, construction, operation, and maintenance of electrodeposition plants is presented in ten main sections: electric equipment; deposition plant; water and drainage; solution formulas; special formulas; solution testing; purification of solutions; safety precautions; testing deposits; and costing.

INDUCTION AND DIELECTRIC HEATING. By J. Wesley Cable. Reinhold Publishing Corporation, 330 West 42d Street, New York 36, N. Y., 1954. 576 pages, $9^{1}/_{4}$ by $6^{1}/_{4}$ inches, bound. $12.50. For each of the types of industrial heating treated separately in this book there is a discussion of general aspects, sources of electric energy, applications, and adaptation to the production line. Uses of induction heating described are those in metallurgy, brazing and welding, soft soldering, forging, and melting. Applications of dielectric heating covered are those in plastics, woodworking, moisture removal, baking foundry cores, and others. An addendum discusses radio interference aspects of the equipment.

PIPE LINE CORROSION AND CATHODIC PROTECTION. A Field Manual. By Marshall E. Parker. Gulf Publishing Company, P. O. Box 2608, Houston 1, Texas, 1954. 102 pages, 8 by $5^{1}/_{4}$ inches, bound. $3.00. This series of twelve articles reprinted from the magazine *World Oil*, 1953–1954, covers methods for obtaining and interpreting field data, and for protecting structures from corrosion. Some additional information, including fundamentals of corrosion and cathodic protection, has been added in appendixes.

RARE METALS HANDBOOK. Edited by Clifford A. Hampel. Reinhold Publishing Corporation, 430 Park Avenue, New York 22, N. Y., 1954. 657 pages, $9^{3}/_{8}$ by $6^{1}/_{4}$ inches, bound. $12.00. Records methods of production, chemical and physical properties, fabrication techniques, and present and potential uses of more than 34 rare or uncommon metals. The emphasis is on the metallic or elemental form, with only minor consideration of compounds. Selected references are given at the end of each chapter.

SNOW CRYSTALS: NATURAL AND ARTIFICIAL. By Ukichiro Nakaya. Harvard University Press, Cambridge, Mass., 1954. 510 pages, $10^{1}/_{4}$ by $7^{3}/_{4}$ inches, bound. $10.00. Based upon research conducted in northern Japan and at Hokkaido University, this study describes the shapes of snow crystals, provides a classification by structures, and discusses in detail their physical nature and electrical properties. A cold-chamber for producing artificial ice and snow is also described.

THE TECHNICAL REPORT. Edited by B. H. Weil. Reinhold Publishing Corporation, 430 Park Avenue, New York 22, N. Y., 1954. 485 pages, $9^{1}/_{4}$ by $6^{1}/_{4}$ inches, bound. $12.00. Based, in part, on the 1953 Symposium on the research report held by the American Chemical Society, this book discusses both the theory and practice of writing, illustrating, editing, duplicating, filing, retrieving, and using technical reports. A chapter is devoted to the oral report, and the question of security-classified reports is considered. Selected references are listed after each chapter.

TELEVISION SIMPLIFIED. By Milton S. Kiver, D. Van Nostrand Company, Inc., 250 Fourth Avenue. New York, N. Y., fourth edition, 1954. 533 pp., 9$^{1}/_{4}$ by 6$^{1}/_{4}$ in., bound. $6.75. Basic principles of television and their most recent applications are explained for the reader with only an elementary knowledge of home sound receivers. Following the pattern of previous editions, the first chapter outlines the units of a television system and succeeding chapters discuss in detail different sections of the receiver. Principal revisions are a new chapter on uhf television and the addition of new material—including information on the National Television System Committee—to the chapter on color television.

A TEXTBOOK OF RADAR. Edited by E. G. Bowen. Cambridge University Press, 32 East 57th Street New York 22, N. Y., second edition, 1954. 617 pp., 8$^{3}/_{4}$ by 5 $^{3}/_{4}$ in., bound. $8.50. Basic principles and the various components are treated in detail in the first 16 chapters which in this edition have received minor corrections. Material on applications in the air, on the ground, and at sea, presented in the last three chapters, has been completely rewritten. Other changes are the compression of military coverage, and a new chapter on recent applications in the physical sciences.

TITANIUM AND ITS COMPOUNDS. By Gordon Skinner, Herrick L. Johnston, and Charles Beckett. Herrick L. Johnston Enterprises, 540 West Poplar Street, Columbus, Ohio, 1954. 174 pp., 10$^{3}/_{4}$ by 7$^{1}/_{4}$ in., bound. $5. Most of the pertinent literature through 1951 is surveyed for data on the preparation and properties of titanium, its hydrides, oxides, halides, nitride and carbide, and the alkaline earth titanates. All the properties of each of the substances are discussed under the specific substance except for the thermodynamic properties which are tabulated in the appendixes. There is a bibliography of 553 references.

TITANIUM AND TITANIUM ALLOYS. By John L. Everhart. Reinhold Publishing Corporation, 330 West 42d Street, New York 36, N. Y., 1954. 184 pp., 6$^{3}/_{4}$ by 4$^{1}/_{4}$ in., bound. $3. A survey of titanium as a commercial material, this book is intended for the engineer or designer interested in using the metal in the solution of his problems. Production and properties are briefly considered as background for a summary of recent technology, including heat treatment, forming and fabricating, joining, machining and grinding, and cleaning and finishing. Chapter references are included.

ACOUSTICS. By Leo L. Beranek. Mc-GrawHill Book Company, Inc., 330 West 42d Street, New York 36, N. Y., 1954. 481 pages, 9$^{3}/_{8}$ by 6$^{3}/_{8}$ inches, bound $9. A textbook for senior and graduate students, with special emphasis on the practical application of electric circuit theory in the solution of problems. It covers the basic wave-equation, sound radiation, acoustic components, microphones, loudspeakers, and horns. Extensive treatment is also given to sound in enclosures, noise reduction, hearing, and related topics.

ELECTRIC POWER TRANSMISSION. The Power System in the Steady State. By John Zaborszky and Joseph W. Rittenhouse. Ronald Press Company, 15 East 26th Street, New York 10, N. Y., 1954. 676 pages, 9$^{1}/_{4}$ by 6$^{3}/_{8}$ inches, bound. $12.50. Designed both as a textbook and a reference work for practicing engineers. Partial contents are the basic structure of power systems; inductive and capacitive reactances; conductor resistance; corona; constants of underground cables; performance in the steady state; voltage and load frequency regulation; power system economics. References are given after many of the sections of the text.

ELECTRICAL EARTHING AND ACCIDENT PREVENTION. Edited by M. G. Say. George Newnes Ltd., London, England, 1954. 248 pages, 8$^{5}/_{8}$ by 5$^{3}/_{4}$ inches, bound. 25s. Nineteen specialists contribute discussions of grounding practice in power systems, in domestic, industrial, and other types of electric installations, and in communication systems. Problems of grounding portable tools, welding equipment, electrically driven machine tools, and so on, are treated separately, and there are sections on measuring and maintenance, regulations, and lightning protection.

THE ELECTROMAGNETIC FIELD IN ITS ENGINEERING ASPECTS. By G. W. Carter. Longmans, Green and Company, Inc., 55 Fifth Avenue, New York 3, N. Y., 1954. 360 pages, 8$^{3}/_{4}$ by 5$^{3}/_{4}$ inches, bound. $7. A systematic, nonmathematical treatment of the theory of electromagnetism with reference to its engineering applications. Fundamentals of conductors, insulators, electric circuit theory, electromagnetic induction, and related topics are discussed, and are illustrated by appropriate problems. The MKS system of units has been adopted.

ELECTRO-MAGNETIC MACHINES. By R. Langlois-Berthelot. Macdonald and Company, Ltd., London, England, 1953. 535 pages, 8$^{3}/_{4}$ by 5$^{3}/_{4}$ inches, bound. 65s. This comprehensive work deals essentially with questions common to the different classes of electromagnetic machines. The six major divisions cover respectively: properties and applications of the various families of machines; construction details and operating characteristics of rotating machines; the machine from the designer's standpoint; the machine from the user's standpoint; abnormal conditions of operation—harmonics, unbalance, transients; general discussions of various ideas, such as flux, reactive power, industrial research, etc.

ELEKTROMAGNETISCHE WELLEN. By Karl Willy Wagner. Verlag Birkhäuser, Basel, Switzerland, 1953. 267 pages, 10$^{3}/_{4}$ by 6$^{3}/_{4}$ inches, bound. Sw.Fr. 33.30. An introduction to the theory of electromagnetic waves as a basis for their application to electrical transmission technique. The book covers fundamentals, reflection and refraction of electromagnetic waves, wired waves, waves in groups of lines, waves in hollow conductors, dipoles, and electric waves in the ionosphere.

ENGINEERS' DREAMS. By Willy Ley. Viking Press, 18 East 48th Street, New York 17, N. Y., 1954. 239 pages, 9$^{1}/_{2}$ by 6$^{1}/_{2}$ inches, bound. $3.50. Nine projects that could be accomplished if it were not for political and economic difficulties are the subject of this book. These include a tunnel under the English Channel, "seadromes," harnessing volcanoes and hot springs, creating a lake in the Congo Basin, shrinking the Mediterranean by building a dam at the Strait of Gibraltar, and obtaining power from the sun, waves, and wind.

FEHLER UND FEHLERSCHUTZ IN ELEKTRISCHEN DREHSTROMANLAGEN. Volume II: Der Fehlerschutz. By Hans Titze. Springer-Verlag, Vienna, Austria, 1953. 302 pages, 10 by 6$^{3}/_{4}$ inches, bound. $9.40. Fault protection is the major topic in this second volume of an advanced textbook on faults and fault protection in 3-phase electric installations. The book deals with electrical characteristics and quantities involved in fault protection, with types of relays, starting circuits, and operating circuits, with the design of protective equipment, and briefly, with testing.

FERROMAGNETIC DOMAINS. By K. H. Stewart. Cambridge University Press, 32 East 57th Street, New York 22, N. Y., 1954. 176 pages, 8$^{3}/_{4}$ by 5$^{3}/_{4}$ inches, bound. $4.75. An outline of the fundamentals of domain behavior: magnetocrystalline anisotropy, magnetostriction, domain arrangement and walls, hindrances to domain wall movements, time effects, and magnetic and thermal energy changers. A list of references is included.

THE GREEN LEAF GUIDE. National Reference Guide for the Patent Field. Field Publications, Port Washington, N. Y., 1954–1955 edition. 64 pages, 9 by 6 inches, paper. $2. Revised and enlarged listings of some 600 companies, classified by fields of interest, provide inventors with a guide to firms now producing or looking for many types of inventions. A separate section explains functions of goverment services and publications in the patent field and gives a table showing how to date a patent from its number.

THE INSULATION OF ELECTRICAL EQUIPMENT. Edited by Willis Jackson. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., 1954. 340 pages, 8$^{3}/_{4}$ by 5$^{3}/_{4}$ inches, bound. $7.75. This compilation of lectures delivered to engineers treats, from the point of view of British practice, electrical and mechanical properties, dielectric permittivity, loss and breakdown; the classification, uses, and limitations of materials for the design of cables, machinery, transformers, etc.; and laboratory, factory, and field testing. Chapter bibliographies are included.

QUALITY CONTROL. By Norbert L. Enrick. Industrial Press, 148 Lafayette Street, New York 13, N. Y., second edition, 1954. 181 pages, 9$^{1}/_{4}$ by 6$^{1}/_{4}$ inches, bound. $4. Retains the character of the first edition—a manual for the practical man. The revision consists of the addition of a second part dealing with additional control charts for variables, control charts for defectives and for acceptance inspection, and with the analysis of variance. The latter subject is handled in a modified form suitable for the beginner.

THE ELECTRONIC MUSICAL INSTRUMENT MANUAL. By Alan Douglas. Pitman Publishing Corporation, 2 West 45th Street, New York, N. Y., second edition, 1954. 221 pp., 8$^{3}/_{4}$ by 5$^{3}/_{4}$ in., bound. $6. A handbook of the theory, basic circuits, electronic elements, and over-all design of the major types of electronic musical instruments. The book discusses the nature of electro-acoustic relationships, explains the production and mixing of electrical oscillations, and describes in detail the commercially available instruments. There is a bibliography.

ELECTRONICS. By Thomas Benjamin Brown. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., 1954. 545 pp., 9$^{1}/_{4}$ by 6$^{1}/_{4}$ in., bound. $7.50. This textbook for a basic course covers thermionic tubes, electron emission, gas in electron tubes, r-f circuits, and instruments. Descriptions of laboratory and demonstration experiments are integrated with the text in order to emphasize practical applications.

ENGINEERING ANALYSIS. By D. W. Ver Planck and B. R. Teare, Jr. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., 1954. 344 pp., 9$^{1}/_{4}$ by 6$^{1}/_{4}$ in., bound. $6. An exposition for graduate and undergraduate students of professional methods for the solution of engineering problems. Most of the book is made up of cases, drawn from electrical, mechanical, and industrial engineering fields, which illustrate how to define a problem, plan an approach, check results, and draw conclusions useful in dealing with future problems.

PAMPHLETS • • • • •

The following recently issued pamphlets may be of interest to readers of "Electrical Engineering." All inquiries should be addressed to the issuers.

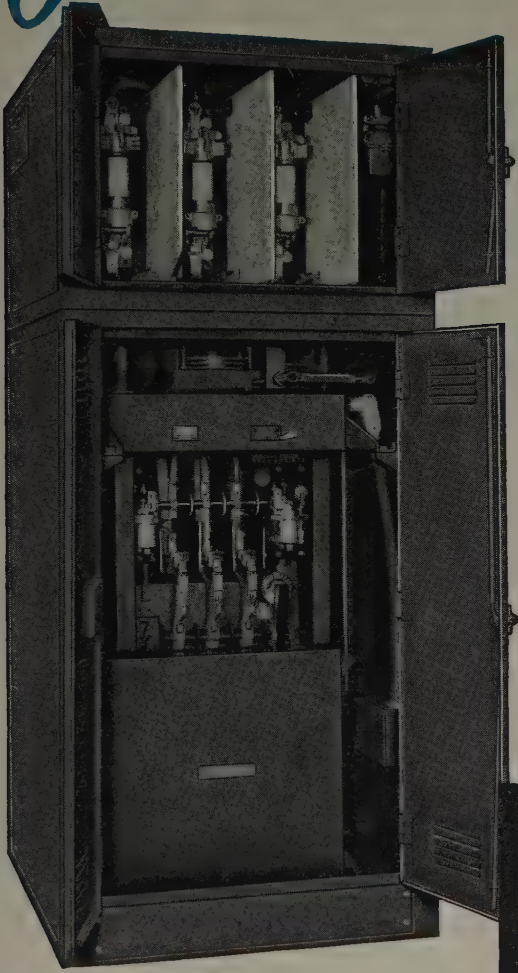
Effective Radio Ground-Conductivity Measurements in the United States. Maps are presented in this circular showing the results of effective ground-conductivity measurements made by various broadcasters and consulting engineers throughout the United States. Over 7,000 radials are shown on the maps, and provisions have been made for entering new measurements, as results become available. National Bureau of Standards Circular *546*. 87 pages, 84 maps. 65¢. Order from the Government Printing Office, Washington 25, D. C.

High-Resolution High-Intensity Scintillation Detector. Measurement of high-intensity nuclear radiation with good time resolution has been made with a scintillation detector consisting of a large coaxial phototube with an opaque photocathode as center conductor and a mesh-type anode as outer conductor. Production models of the design are illustrated and details given of tests for voltage breakdown, variations of photosensitivity, and space-charge effects. 18 pages, with charts, diagrams, and photographs. 50¢. Available from Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C.

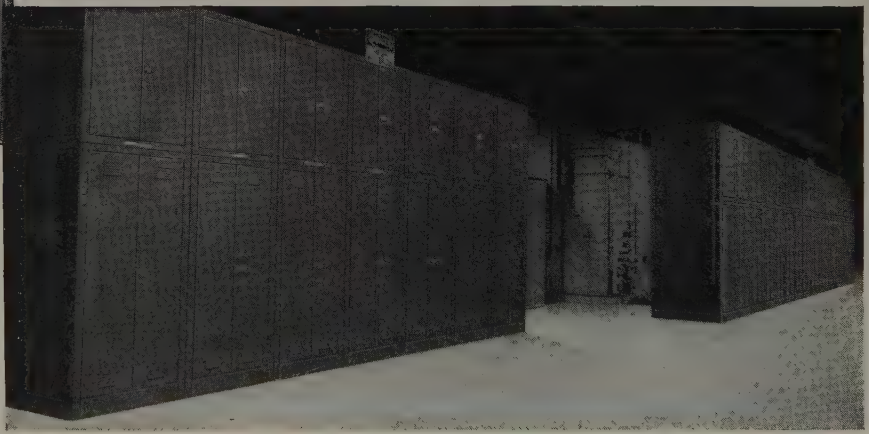
Manpower Resources in Mathematics. This report on the professional characteristics, employment, and earnings of mathematicians in the United States has been issued by the National Science Foundation. It is based on information supplied to the National Scientific Register in 1951 by about 2,400 mathematicians. 20¢. Available from the Superintendent of Documents, Government Printing Office, Washington 25, D. C.

Oil Immersed

HIGH VOLTAGE
ACROSS-THE-LINE AND REDUCED VOLTAGE CONTROL OF CUBICLE CONSTRUCTION



Standard units consist of: insulated round bus with terminals for incoming line; low voltage control transformer; current limiting, high interrupting capacity fuses; quick acting, heavy duty contactor with non-freezing contacts; magnetic overload relays with instantaneous and inverse time element electrically reset; sealed-off motor terminal compartment; low voltage control center; self-contained tank lowering device; electrical and mechanical door interlock. Additional features such as watt-hour meter, voltmeter, ammeter, potential switch, etc., may be provided to meet the requirements of specific applications. These self-contained, self-supporting control units are designed for single or group mounting—for indoor or outdoor service.

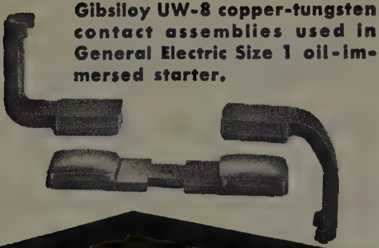


ABOVE—Type 700-B, high voltage combination starter of Cubicle construction. RIGHT—Group mounting of high voltage Cubicles shown in actual use.

ROWAN CONTROL

THE ROWAN CONTROLLER CO., BALTIMORE, MD.

Gibsiloy UW-8 copper-tungsten contact assemblies used in General Electric Size 1 oil-immersed starter.



CONTACTOR LIFE **DOUBLED** by changing to **Gibsiloy** copper-tungsten contacts

General Electric Size 1 oil-immersed contactor used in Size 1 oil-immersed starter.

General Electric tests showed that fine silver contacts used satisfactorily in G. E. air contactors were subject to excessive wear when applied to oil-immersed starters. To overcome this trouble, General Electric tested copper-tungsten Gibsiloy UW-8 in their Size 1 oil-immersed starter and found it provided more dependable service, longer life and less maintenance.

In fact, the efficiency of Gibsiloy UW-8 contacts doubled the life of the contactor.

Gibsiloy UW-8 withstood the severe and confined arcing in the starter operation, with very little erosion.

Similar advantages of Gibsiloy UW-8 can be enjoyed in tap changers, other starters and oil-immersed apparatus. Write for information, and let us help solve your electrical contact problems. The same experience in designing and producing electrical contacts which provided Gibsiloy UW-8 for the G. E. starter is available to you.

Gibson Catalog C-520 is yours free. Write for it.

CONTACT GIBSON FIRST

Gibsiloy ELECTRICAL CONTACTS

Manufactured by
GIBSON ELECTRIC COMPANY

8348 Frankstown Ave., Pittsburgh 21, Pa.

INDUSTRIAL NOTES ....

General Electric News. Decentralization of the General Electric tube department's marketing activity, and creation of a new marketing section in each of the department's three subdepartments, has been announced by the General Electric Company. The organizational change will stress a higher degree of product specialization and long range product planning. Reed V. Bontecou has been appointed manager of marketing for receiving tubes. He previously was product manager for tube products at tube department headquarters, Schenectady, N. Y. He will make his headquarters in Owensboro, Ky. Named to a parallel position for cathode ray tubes is Richard A. Norman. Before his new appointment he was manager of Syracuse manufacturing for the CRT subdepartment. He will make his headquarters at Syracuse, N. Y. The new marketing manager for industrial and transmitting tubes is Milton J. Strehel. He previously was manager of marketing administration at tube department headquarters. He will make his headquarters at Schenectady. Plants operated by the subdepartments are at Owensboro, Ky., Tell City, Ind., and Anniston, Ala. for receiving tubes; at Syracuse and Buffalo, N. Y. for cathode ray tubes; and at Schenectady and Scranton, Pa. for industrial and transmitting tubes.

The appointment of F. C. Tucker as manager, Eastern sales, for the company's plastics department has been announced. The position is a newly created one, involving coverage of New York, Pennsylvania and the Atlantic Seaboard. In his new post, Mr. Tucker will be responsible for sale of the department's line of custom molded plastics products for the refrigeration, electronics, electrical and other industries.

Westinghouse Notes. H. C. McDaniel has been appointed manager of technical information for the Westinghouse Electric Corporation. Mr. McDaniel, formerly manager of technical publicity, will supervise both the technical publicity operations and the Westinghouse Engineer magazine. He replaces C. A. Scarlott, former technical information manager and editor of the Engineer, who resigned to accept the position of manager of technical information services at the Stanford Research Institute, Palo Alto, Calif.

W. Dee Shepherd has been appointed sales manager of the company's Atomic Power Division. Mr. Shepherd was formerly contract manager for the Atomic Power Division. He will now be responsible for the sale of all products and services of the division including canned motor pumps and other products to be made at the Atomic Equipment department plant near Cheswick, Pa.

RCA Establishes New Operations Department. Establishment of a special RCA color kinescope operations department, devoted exclusively to the engineering and manufacturing of color television picture tubes, has been announced. Harry R. Seelen has been appointed manager of the new department, which will have its headquarters at the company's plant in Lancaster, Pa.

Federal Pacific Acquisition. Federal Pacific Electric Company, Newark, N. J. has acquired the Gardner Electric Manufacturing Company, San Francisco, Calif. Since transformers are often sold as an integral part of switchgear equipment, the company feels that expansion into transformer manufacturing is a natural development in their growing switchgear activities.

IBM Appointment. William B. Hilbert has been appointed production manager at the International Business Machines Corporation's Endicott, N. Y. plant. Mr. Hilbert joined the company in New York in 1930.

Magnavox Changes. The Magnavox Company has announced expansion of its operations into the field of fundamental electronic research, with emphasis on the development of electronic computing devices for both military and industrial use. The new division will be known as Magnavox Research Laboratory, and is located in Los Angeles, Calif. Dr. Ragnar Thorensen was named director of research to head full scale operation of the company's new research and engineering laboratory. Concurrently, David M. Goodman was named administrative head of the laboratory, and as West Coast regional director of the Industrial and Defense Products Divisions, with headquarters in the laboratory to facilitate close sales contact with West Coast manufacturers.

Sprague to Head Defense Group. Julian K. Sprague, of Williamstown, Mass., president of the Sprague Electric Company, of North Adams, has been named chairman of the advisory group on electronic parts of the Department of Defense. The appointment was made in Washington by Assistant Secretary of Defense for Research and Development Donald A. Quarles. Serving with Mr. Sprague on the group will be Leslie J. Woods, vice-president in charge of engineering of the Philco Corporation, Estill I. Green, director of transmission apparatus development at Bell Telephone Laboratories, Inc., A. W. Rogers of the Squier Signal Laboratory at Fort Monmouth, N. J., Edward Mroz of the Electronics Division of the United States Navy Bureau of Ships, and Amos Petit of the United States Air Force Wright Development Center at Dayton, Ohio.

Kaiser Aluminum Appointment. Kaiser Aluminum and Chemical Sales, Inc., has announced the appointment of J. P. Moran as building wire specialist, in charge of the company's national sales program

(*Continued on page 24A*)

at Detroit's NORTHLAND PROJECT

vital energy for a shopping wonderland
supplied by I-T-E dry-type, double-ended Unit Substations

Eleven I-T-E metal-enclosed Unit Substations, rated 1500 and 2000 kva, service the Center's immense lighting and power requirements. And to assure service continuity, Northland's electrical system features I-T-E Selective Tripping devices on the circuit breakers, which *isolate* system faults by interrupting only the circuit nearest the fault.

From the start, important engineering aid was given Northland by I-T-E application engineers. Thanks to this close cooperation, power distribution equipment was on hand *when needed* to fit right in with tight construction schedules.

I-T-E is proud of its place as a *major* contributor of quality power distribution equipment for the "world's largest shopping center."

AT NORTHLAND—

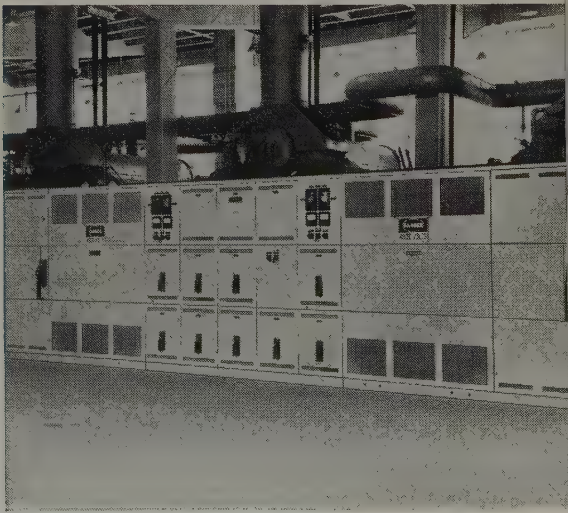
I-T-E Substations service:

- interior lighting
- exterior lighting
- display lighting
- elevators
- conveyors
- escalators
- pumps & blowers
- air conditioning
- compressors
- refrigeration

For details contact the I-T-E field office nearest you. Look in your classified directory under "Electric Equipment."

I-T-E UNIT SUBSTATIONS
service all interior lighting needs of the Center.

I-T-E UNIT SUBSTATIONS
installed in basement of Hudson Building for 4800—120/208 volt lighting distribution.



I-T-E UNIT SUBSTATION
installed in Utility House for 4800—480 volt power distribution.

HE SYMBOL OF QUALITY SWITCHGEAR

I-T-E CIRCUIT BREAKER COMPANY

19TH AND HAMILTON STREETS, PHILADELPHIA 30, PA.

UNIT SUBSTATIONS

RADIO INTERFERENCE and FIELD INTENSITY* measuring equipment

Stoddart NM-20B • 150kc to 25mc

Commercial Equivalent of AN/PRM-1A

WIDE FREQUENCY RANGE . . . Covering the most widely used portion of the radio-frequency spectrum, the NM-20B is a precision instrument designed for field or laboratory measurement, analysis and interpretation of all types of radiated and conducted radio-frequency signals and interference. Sturdy dependability, broad frequency range and a full complement of accessories fit this instrument's outstanding characteristics to an impressive variety of applications. Includes standard broadcast band, radio range, WWV, ship-to-shore, amateur and other communication frequencies.

SELF-CONTAINED BATTERIES . . . Battery power allows portable operation of the NM-20B. The ac power supply permits operation from 105 to 125 volts or 210 to 250 volts ac at any frequency between 50 cps and 1600 cps. Its versatile power requirements and special weather-proof construction provide unlimited field operation.

PICKUP DEVICES . . . Pickup devices available for use with the NM-20B include the loop and loop probe, rod antennas and matching impedances for conductive inputs. These permit unlimited usefulness in measuring both conducted and radiated interference.

Stoddart RI-FI* Meters cover the frequency range 14kc to 1000mc

VLF
NM-10A, 14kc to 250kc
Commercial Equivalent of AN/URM-6B. Very low frequencies.

VHF
NM-30A, 20mc to 400mc
Commercial Equivalent of AN/URM-47. Frequency range includes FM and TV bands.

UHF
NM-50A, 375mc to 1000mc
Commercial Equivalent of AN/URM-17. Frequency range includes Citizens band and UHF color TV band.

STODDART AIRCRAFT RADIO Co., Inc.
6644-B Santa Monica Blvd., Hollywood 38, California • Hollywood 4-9294

(Continued from page 16A)

for aluminum building wire. In his new position, Mr. Moran will be responsible for co-ordinating the Kaiser Aluminum building wire program and will report to G. N. Houck, manager of electrical products, Chicago, Ill. He will be assigned temporarily to the corporation's sales office in Philadelphia, Pa.

Cal-Tech Scientist Joins Ramo-Wooldridge. Dr. Louis G. Dunn resigned as director of the Jet Propulsion Laboratory, California Institute of Technology, to join The Ramo-Wooldridge Corporation, Los Angeles, Calif. as associate director of the new Guided Missile Research Division. Dr. Dunn will work with Dr. Simon Ramo, who, in addition to his duties as executive vice-president of Ramo-Wooldridge, will be director of the division, and with Dr. Ralph P. Johnson, vice-president for research and development.

Honeywell Appoints Maves. George Maves, manager of the Boston sales office of Minneapolis-Honeywell Regulator Company since 1948, has been promoted to the position of manager of the company's Pacific region, with headquarters in Los Angeles, Calif. He succeeds Gavin S. Younkin, who recently was named general sales manager for the company. R. W. (Bob) Forster, who has been manager of the Buffalo, N.Y. sales offices, has been named to succeed Mr. Maves as Boston manager.

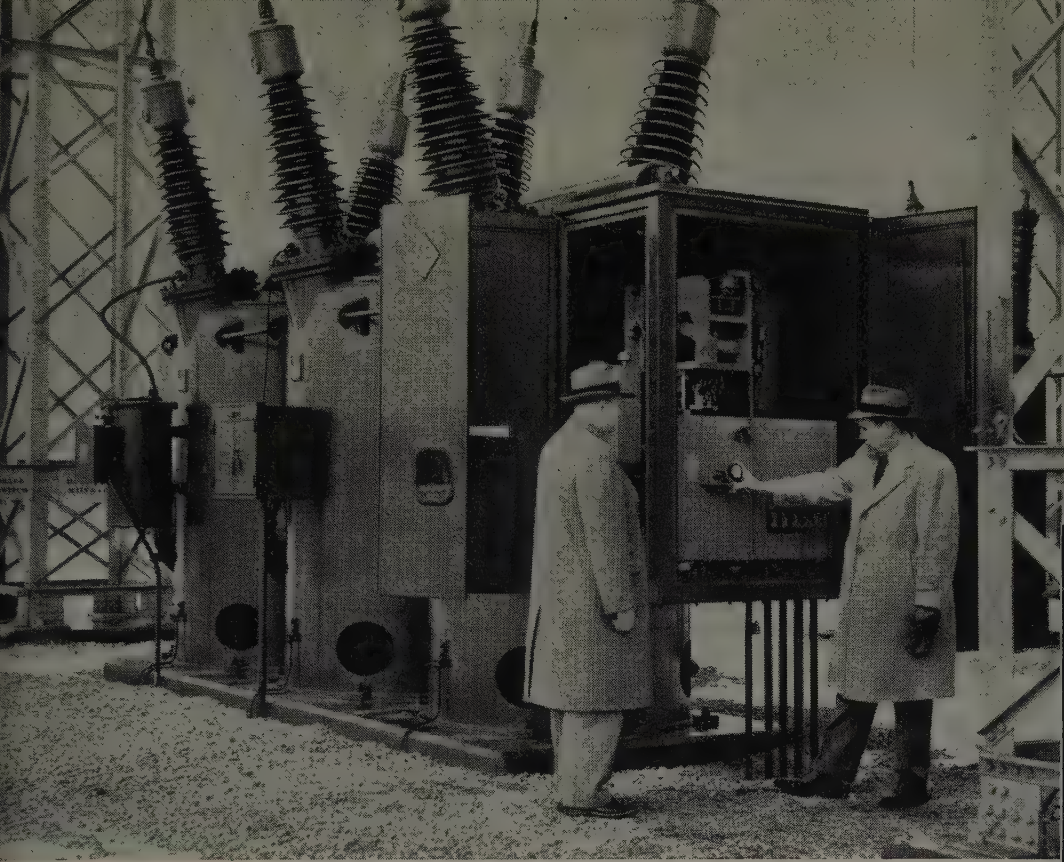
Norman Joins Sprague. George H. L. Norman has joined the Sprague Electric Company, of North Adams, Mass. as co-ordinator of the company's activities in the field of electronic computer components. Mr. Norman comes to Sprague from the Corning Glass Works, where he was general sales manager of the New Products Division. Mr. Norman is well known in the electronic components industry, where he previously spent a total of 17 years with the Aerovox Corp.

Marcus to Expand. Al Marcus, president of Marcus Transformer Company, has announced the transfer of manufacturing operations to an enlarged plant in Rahway, N. J. Situated on 18 acres of land, adjoining the main line of the Pennsylvania Railroad, the move consolidates, under one roof, the operation of two former plants in Hillside, N. J. The Marcus Company has already tripled the size of their office area, and plan the erection of another building within 6 months for additional manufacturing and storage facilities.

NEW PRODUCTS • •

Process Timer. A new process timer, featuring 1-knob control has been announced by the General Electric Company's instrument department. Designated

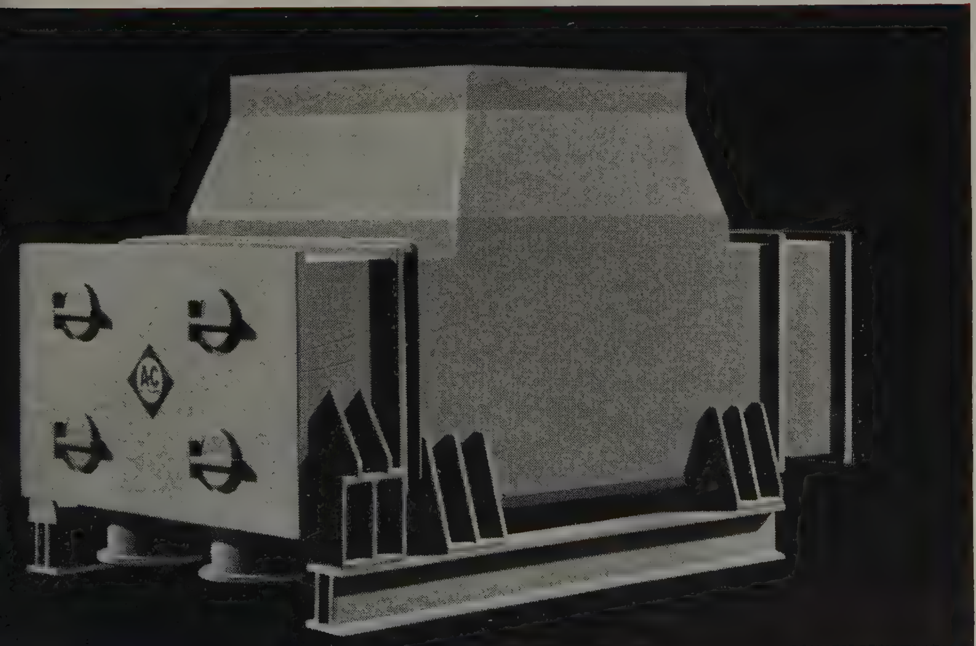
(Continued on page 30A)



New Simplicity! *Pneu-Draulic* operating mechanism for breakers utilizes hydraulic principle instead of air. This reduces dirt and moisture hazards, adds reliability to breakers. These 115-kv breakers with *Pneu-Draulic* operators have been in service more than a year.

Developments

A Look At Tomorrow! This 5000-kva power transformer, designed for 600 or 800-kv service, was built to help advance engineering knowledge toward possible future requirements.



Space-Saving Condenser! Latest 100,000-square-foot condenser, now being built, illustrates trend to rectangular shape, which permits savings in plant construction cost. Model allows unusual view of unit. This condenser features multi-steam path design for low "terminal difference," high condensate temperature and low absolute pressure.

A-4484

CHALMERS

7 Reasons why Regohm is a natural for your control system

This compact, electro-mechanical controller provides sensitivity, speed of response and system stabilization under severe operating conditions. Its design and operating features have made Regohm useful for automatic control systems in which heavier, more expensive and complex, but less accurate equipment had previously been the only available solution.

① **SMALL SIZE** · Regohm is a compact, plug-in device; lightweight, extremely rugged and position-free. The unit's small size does not limit its power-handling capacity. This makes Regohm a "natural" where economy of space and weight are your major considerations.

② **POWER AMPLIFYING** · Regohm is a high-gain electro-mechanical power amplifier. Milliwatt variations in signal energy can control energy changes millions of times greater.

③ **IMPEDANCE MATCHING** · Signal and controlled circuits are isolated, both electrically and structurally. Signal coils may have ratings from 0.01 to 350 amperes. Controlled resistors on a panel in which Regohm is plugged, can have values from zero to infinity, depending on the controlled system.

④ **SYSTEM STABILIZING** · A thoroughly reliable, sturdy dashpot aids in system damping. It can easily and readily be adjusted over a wide range to match the dynamic characteristics of the Regohm to those of your present system.

⑤ **ANALYTICALLY DEFINABLE** · The response of Regohm is independent of the rest of the servo system. Its response characteristic can be expressed in terms of conventional "transfer functions." Regohm acts as an integrating error-rate proportional controller. No appreciable steady-state error can occur. Regohm's effect can be calculated in advance, simplifying the design and facilitating the prediction of performance.

⑥ **CONTINUOUS CONTROL** · In "closed loop" systems a high-speed averaging effect occurs as Regohm's armature oscillates over a small amplitude. This provides intermediate values between step resistances and results in continuous, stepless control in systems operating at power frequencies and below.

⑦ **LONG LIFE** · In properly engineered installations, Regohm's life is measured in years. Plug-in feature simplifies replacement and maintenance—there are no parts to renew or lubricate. Shelf life is substantially unlimited.

Our engineering and research facilities can help you apply Regohm to your servo system or regulator problem. Write for Bulletin 505.00, analyzing Regohm's characteristics and applications. Address Dept. EN, ELECTRIC REGULATOR CORPORATION, *Norwalk, Connecticut.*

REGOHM

CONTROL COMPONENT IN: Servo systems • battery chargers • airborne controls • portable and stationary generators • marine radar • inverters • locomotive braking systems • mobile telephones • guided missiles • signal and alarm systems • telephone central station equipment • magnetic clutches • railroad communication systems.

(*Continued from page 24A*)

the *TSA-21*, this new product will control the timed, simultaneous closing of one electric circuit, and opening of another. Ideal for equipment which requires easily adjustable and accurately timed operations from an initial impulse, the *TSA-21* includes one set of time-opening main contacts and one set of electrically separate time-closing main contacts. The trip point of the main contacts can be adjusted by an external knob. Each timer has a set of instantaneous contacts which can be used independently or as hold contacts for the timer solenoid. The time scale of the new product is calibrated from 0 to 100 per cent.

Aluminum Alloy. An aluminum alloy for conducting electricity, Number *2EC*, has been developed by Aluminum Company of America. This new alloy is a tailor-made material developed to meet the high performance requirements of the electrical equipment manufacturing industry. Number *2EC* aluminum conductor alloy has superior mechanical properties, with slight sacrifice in electrical conductivity over other aluminum alloys used for conductor purposes. Such properties are important especially for applications requiring high yield strength and low creep.

Power Transistor. A combination of mounting and physical design has made possible the 1-watt rating of a new germanium power transistor now in pilot production by the Westinghouse Electronic Tube Division. The ribbed surface provides cooling capacity for the 1-watt collector dissipation rating. Additional cooling is accomplished by fastening the unit in thermal contact with the chassis. The new p-n-p transistor, *2N71*, is applicable to any low-frequency circuit, such as class *A* amplifiers, where output power is desired.

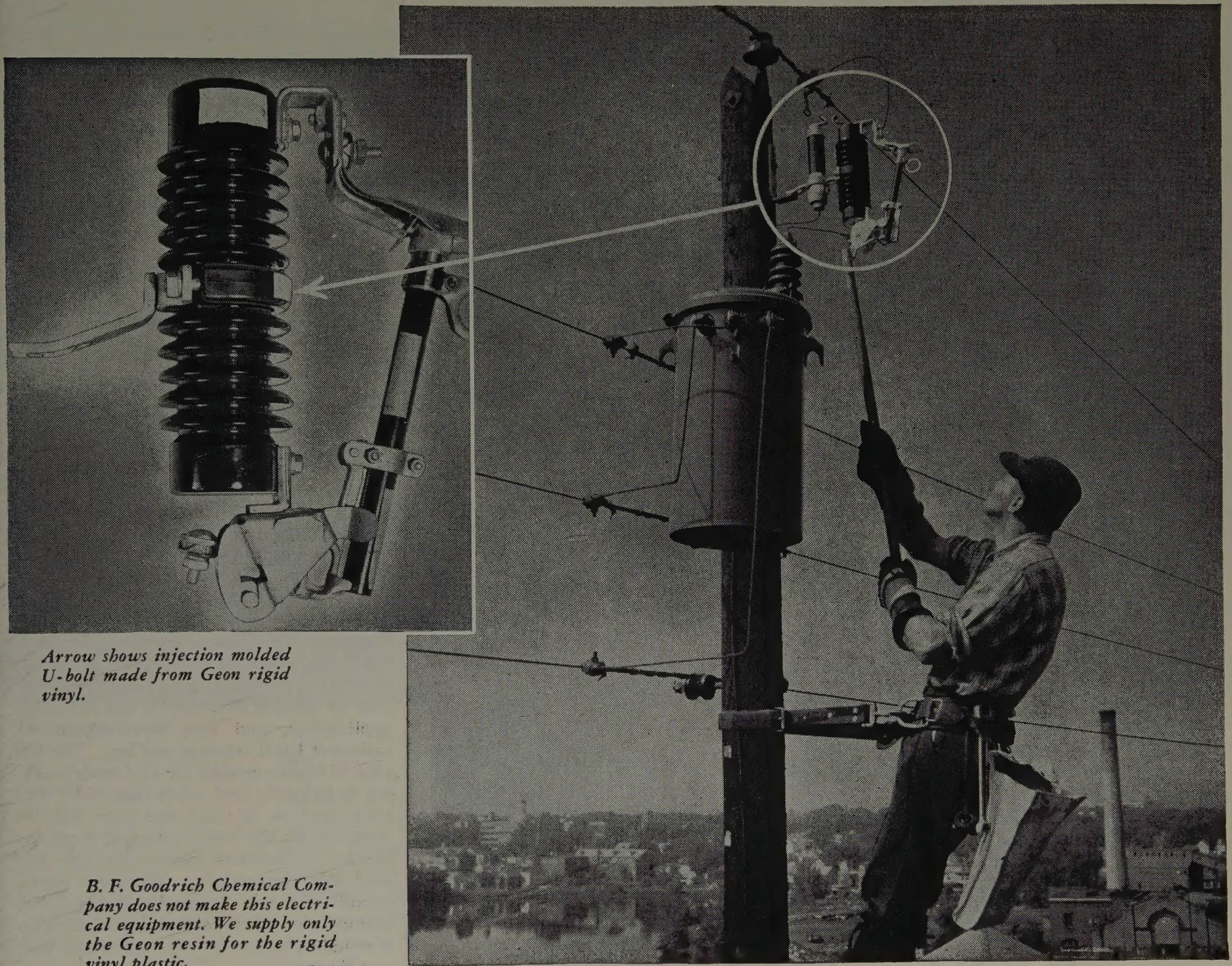
Servo Motors. G-M Laboratories, Inc., has announced production of two new servo motors for use in electronic control circuits. The motors are available in standard frame sizes 15 and 18, which are 1.437 inch and 1.750 inch in diameter, respectively, and are designed for use in a wide variety of equipment such as computers, gun sights, navigation equipment, guided missile, radar, and similar applications. For full information write to G-M Laboratories, Inc., 4300 North Knox Avenue, Chicago 41, Ill.

Molded Plastic Seals Resistors. The new *MW* insulated wire-wound resistor now being distributed by International Resistance Company, Philadelphia, Pa., is virtually impervious to the elements because of a plastic incasement. *MW* resistors are completely insulated and protected in a durable Plaskon Alkyd molding compound that is a product of Barrett Division, Allied Chemical and Dye Corporation. Moisture and salt spray are common causes of trouble in ordinary wire-wound equipment, but the pressure molded Plaskon Alkyd forms an almost perfect seal. The

(*Continued on page 40A*)

Another new development using

B. F. Goodrich Chemical ***raw materials***



Arrow shows injection molded U-bolt made from Geon rigid vinyl.

B. F. Goodrich Chemical Company does not make this electrical equipment. We supply only the Geon resin for the rigid vinyl plastic.

New cutout "Bird-Proofed" by Geon

ELECTRIC service is occasionally disrupted by birds and small animals that short circuit line equipment. But General Electric has "bird-proofed" their open drop-out fuse cutouts with high impact and high dielectric strength Geon rigid vinyl plastic.

The G. E. cutouts protect equipment and lines from overloads and short circuits and expedite location of storm-damage for repairs. The unit is mounted to its hanger by means of a U-bolt which is insulated with injection molded Geon rigid vinyl. Geon was selected for this application because of its high dielectric and mechanical strengths and excellent weathering properties.

This is another example of Geon's usefulness in the electrical field. Geon vinyl insulating compounds were developed to meet the exacting requirements of the electrical power industry, equipment manufacturers and Underwriters' Laboratories. For information on how Geon can solve your difficult insulating problem, please write Department GS-5, B. F. Goodrich Chemical Company, Rose Building, Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ontario.

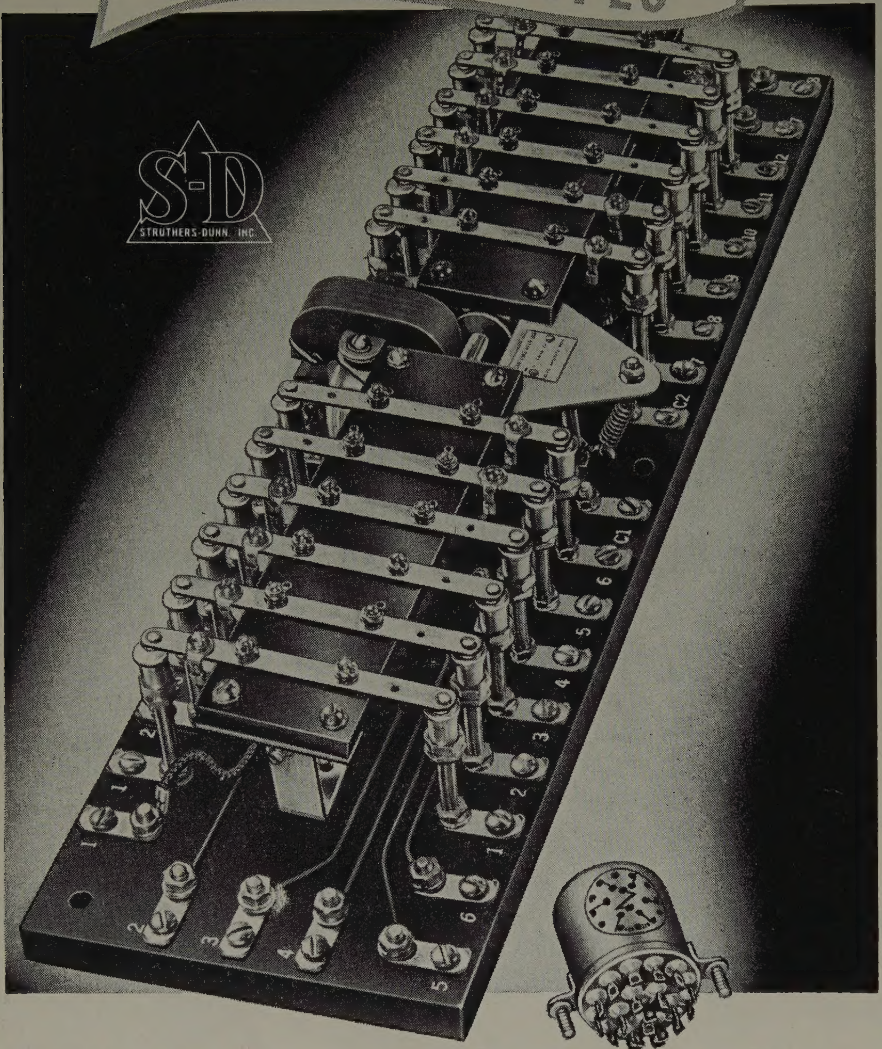
A TRADE MARK OF B. F. GOODRICH CHEMICAL COMPANY
Geon
Polyvinyl Materials
A DIVISION OF THE B. F. GOODRICH COMPANY

GEON RESINS • GOOD-RITE PLASTICIZERS . . . the ideal team to make products easier, better and more saleable.

GEON polyvinyl materials • HYCAR American rubber • GOOD-RITE chemicals and plasticizers • HARMON colors

STRUTHERS-DUNN

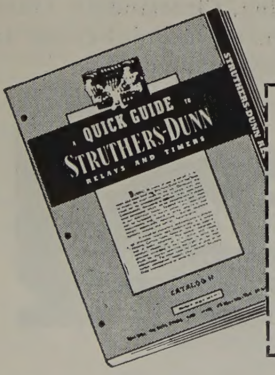
5,348 RELAY TYPES



. . . from the smallest to the largest
. . . and everything in between!

✓ Industrial ✓ Electronic ✓ Military

QUICK GUIDE . . . to the most popular of the S-D 5,348 relay types.



STRUTHERS-DUNN, Inc.,
Pitman, N. J.
Without obligation send the 20-page "Quick Guide" to S-D relays and timers.
Name..........
Position..........
Company..........
Address..........

SALES ENGINEERING OFFICES IN: ATLANTA • BALTIMORE • BOSTON • BUFFALO • CHARLOTTE • CHICAGO CINCINNATI • CLEVELAND • DALLAS • DETROIT • KANSAS CITY • LOS ANGELES • MINNEAPOLIS • MONTREAL NEW ORLEANS • NEW YORK • PITTSBURGH • ST. LOUIS • SAN FRANCISCO • SEATTLE • SYRACUSE • TORONTO

(*Continued from page 30A*)

resistor was tested under extremely adverse atmospheric conditions and found to be unaffected.

Compact Studio Switchgear. A compact, self-contained studio switcher engineered for the special requirements of color television broadcast operations has been announced by the Engineering Products Division, Radio Corporation of America. The switcher provides 9 inputs, 3 outputs, and a previewing channel, and is particularly suited for monochrome broadcasting.

The new switcher, *TS-11A*, is designed to handle camera switching, fading, and lap-dissolves in the studio control room, as well as remote and network signal inputs. It provides extra contacts on all switch positions for such special applications as simultaneous audio-video switching.

Design and engineering features, essential for proper transmission of color signals, include: smooth, low-frequency roll-off to free the system of switching transients and low-frequency bounce; 50 db isolation between output lines; shock-mounted preamplifier chassis and ruggedized tubes to eliminate microphonics; feedback amplifiers in the output stage; and sending-end terminations.

Enclosed Air Circuit Breakers. Roller-Smith full plug-in type enclosed air circuit breakers provide the best possible protection for general commercial and industrial applications, and now have continuous ratings of 1,600 amperes and less. The full plug-in feature enables the air circuit breakers to be easily and safely installed. The back portion of the enclosure can be mounted on the wall, separated from the breaker to facilitate making the line and load side connections. With the wiring completed, the standard Roller-Smith manually or electrically operated breaker is readily plugged into the stationary contact fingers.

Insulated Flexible Braid Connector. A flexible braid connector that features a protective vinylite covering has been developed by Burndy Engineering Company, Inc. Made of extra flexible, flat, tinned copper braid with seamless copper ferrules on each end, the new insulated connector provides protection against corrosive atmosphere and abrasive particles. The entire braid section is covered with vinylite and secured within the ferrules by compression. The new connector is especially suited to plating operation applications. For further details, write Burndy Engineering Company, Inc., Norwalk, Conn.

Ground Wire Bracket. A ground wire bracket for attaching overhead ground wire to existing, or new tower, or H-Frame construction has recently been made available by The Porcelain Insulator Corporation of Lima, N. Y. Tests show that this new design offers many advantages over rigid-type clamps, the principal one being that it eliminates damage due to ground wire vi-

(*Continued on page 56A*)

The Panama Canal

Laying Kerite Cable across the Isthmus, 1908

Since it was first manufactured almost a century ago, Kerite insulated cable has been closely integrated with the international development of the communications industry. One of the most important installations of Kerite cable was made in 1908 across the Isthmus of Panama, a distance of 50 miles, uniting the Atlantic and Pacific ocean cables.

Early performance records of this outstanding product indicated that Kerite cable was unusually well equipped to withstand the extremely severe conditions attending this tropical installation. This cable, originally laid on the ground in the jungle, was submerged for 30 miles in Gatun Lake upon completion of the canal.

As a result of the operation of this initial cable, a second one was installed in underground ducts in 1918 under the supervision of Mr. C. R. R. Harris, now President of The Kerite Company. Subject to similar adverse conditions, this cable continues to perform the important function for which it was designated at a critical point in communications history.

The value and service life of a product can be no greater than the integrity and craftsmanship of its maker.

DAYS KERITE
100th Anniversary
THE KERITE COMPANY
1854
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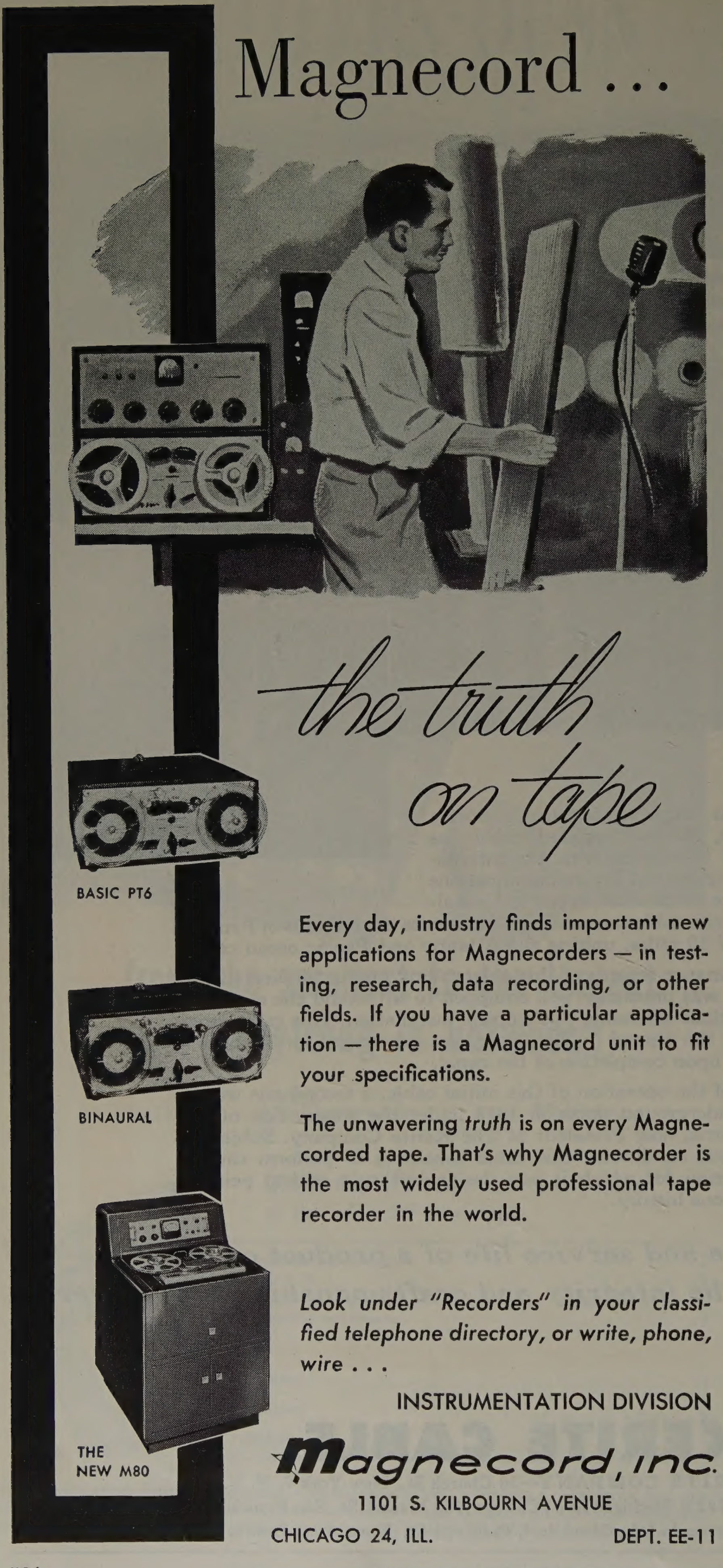
KERITE CABLE

THE KERITE COMPANY—30 Church St., New York 7, N. Y.
Offices also at 122 S. Michigan Ave., Chicago; 582 Market St., San Francisco;
3901 San Fernando Rd., Glendale 4, Calif.; 31 St. James Ave., Boston



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(Continued from page 40A)

bration, thereby assuring a permanent, trouble-free installation. Bracket can be furnished with various drillings for attachment to steel or wood structures. The forged steel plate is completely galvanized and is available with either forged steel or malleable iron clamps to fit all types and sizes of ground wire.

TRADE LITERATURE

Elco Varicons. A new 24-page catalogue "Elco Varicons," has been announced as available from the Elco Corporation, "M" Street, Below Erie Avenue, Philadelphia 24, Pa. The company's complete line of equipment is covered including an explanation of their revolutionary miniature connector system. Copies of this publication may be obtained by writing to the manufacturer on your company letterhead.

Electric Motor Control. The Furnas Electric Company, Batavia, Ill. has announced the publication of a new 140-page electric motor control catalogue. Primarily divided by major classifications, this catalogue contains engineering and design data including wiring diagrams. Among the more than 2,700 items listed are magnetic starters and contactors, combination starters, control panels, drum controllers, master, and foot and pressure switches. For a free copy of catalogue number *101*, write Furnas Electric Company, 1063 McKee Street, Batavia, Ill.

G-E Distribution Transformer Features. A new 24-page, 3-color publication describing features of distribution transformers has been announced available by General Electric Company, Schenectady 5, N. Y. Designated *GEA-6070*, this booklet covers the design features, advantages of impulse testing, nitrile rubber gaskets, Strenicor terminal clamps, clamp-type H-V connectors, bushing terminals which handle both aluminum and copper conductors, one-piece cover bands, Thyrite* Magne-Valve arresters, Super Melaglyp paint, and General Electric Spirakore* construction.

Cathodic Protection. A booklet covering "whys" and "hows" of cathodic protection has been announced by the National Carbon Company. This 12-page catalogue section is a complete reference work on mitigation of corrosion of underground and submerged metal structures by application of an impressed current cathodic protection system using National graphite anodes. Copies of this new booklet, *Catalogue Section S-6500*, may be obtained by writing National Carbon Company, a Division of Union Carbide and Carbon Corporation, 30 East 42d Street, New York 17, N. Y.

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